

Indoor Environmental Quality

SS	WE	EA	MR	EQ	ID
Overview					

Americans spend on average 90% of their time indoors where the U.S. Environmental Protection Agency reports that levels of pollutants may run two to five times—and occasionally more than 100 times—higher than outdoor levels¹. Similarly, the World Health Organization reported in its Air Quality Guidelines for Europe, Second Edition² that most of an individual's exposure to many air pollutants comes through inhalation of indoor air. Many of these pollutants can cause health reactions in the estimated 17 million Americans who suffer from asthma and 40 million who have allergies, thus contributing to millions of days absent from school and work. Outbreaks of Legionnaires' disease and sick building syndrome confirm the relationship of indoor air quality to the occupant health.

Over the past twenty years, research and experience has improved our understanding of what is involved in attaining high Indoor Environmental Quality (IEQ), and revealed manufacturing and construction practices that can prevent many IEQ problems from arising. The use of better products and practices has reduced potential liability for design team members and building owners. The results are increased market value for buildings with exemplary IEQ and greater productivity for the occupants. In a case study included in the 1994 publication *Greening the Building and the Bottom Line*, the Rocky Mountain Institute cites how improved indoor environmental quality improved worker productivity by 16%, netting a rapid payback on the increased capital investment.

Preventing IEQ problems is generally much less expensive than identifying and solving them after they occur. One practical way to prevent IEQ problems from arising is to specify materials that release fewer and less harmful chemical compounds. Evaluation of the properties of the adhesives, paints, carpets, composite wood products and furniture, and specifying those materials with low levels of potentially irritating off-gassing, can reduce occupant exposure. Scheduling of deliveries and sequencing construction activities can reduce material exposure to moisture and absorption of off-gassed contaminants. Protection of air handling systems during construction and a building flush-out prior to occupancy further reduces potential for problems arising during the operational life of a building.

Using higher ratios of filtered outside air, increasing ventilation rates, managing moisture, and controlling the level of contaminants in the cleaning substances used can provide optimal air quality for building occupants. Installation of automatic sensors and controls to maintain proper temperature, humidity, and rates of outdoor air introduced to occupied spaces also plays a key role in maintaining optimal air quality. Use of sensors to alert building maintenance staff to potential Indoor Air Quality (IAQ) problems such as carbon dioxide (CO₂) build-up in an occupied space can also effectively balance energy and IEQ issues.

Occupant well-being can be improved by providing views to the exterior and by providing daylighting. In addition, providing occupants with the ability to

Overview of LEED® Prerequisites and Credits

EQ Prerequisite 1

Minimum IAQ Performance

EQ Prerequisite 2

Environmental Tobacco Smoke (ETS) Control

EQ Credit 1

Outdoor Air Delivery Monitoring

EQ Credit 2

Increased Ventilation

EQ Credit 3

Construction IAQ Management Plan—During Construction

EQ Credit 4.1

Low-Emitting Materials—Adhesives & Sealants

EQ Credit 4.2

Low-Emitting Materials—Paints & Coatings

EQ Credit 4.3

Low-Emitting Materials—Carpet Systems

EQ Credit 4.4

Low-Emitting Materials—Composite Wood & Agrifiber Products

EQ Credit 4

Supplemental Information

EQ Credit 5

Indoor Chemical & Pollutant Source Control

EQ Credit 6

Controllability of Systems—Thermal Comfort

EQ Credit 7

Thermal Comfort—Design

EQ Credit 8.1

Daylight & Views—Daylight 75% of Spaces

EQ Credit 8.2

Daylight & Views—Views for 90% of Spaces

1 United States Environmental Protection Agency. *Healthy Buildings, Healthy People: A vision for the 21st Century*. October 2001. www.epa.gov/iaq/hbhp/hbhptoc.html

2 World Health Organization. *Air Quality Guidelines for Europe, Second Edition*. 2000. www.euro.who.int/document/e71922.pdf

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control their personal thermal environment can reduce hot/cold complaint calls and generally raise occupant satisfaction levels which can lead to increases in productivity.

The joint efforts of the owner, building design team, contractors, subcontractors and suppliers are integral to providing a quality indoor environment.

In their design and construction, core and shell projects can affect indoor air quality in two general manners. Most directly, the design and construction team is able to directly influence the quality of those spaces that they have control over. This might be lobby spaces, central circulation areas, and building cores. Second, but most importantly, the core and shell design and construction decisions can directly affect the indoor environmental quality of tenant spaces outside of the control of

the core and shell submittal. Examples of this include ventilation design and careful design consideration for tenant ability to optimize daylight and views. Core and shell projects should consider how their decision could enable tenant fit-outs to deliver high Indoor Environmental Quality to the final occupants, the tenants.

Indoor Environmental Quality Credit Characteristics

Table 1 shows which credits were substantially revised from LEED-NC Version 2.2, which credits are eligible to be submitted in the Design Phase Submittal, and which project team members are likely to carry decision-making responsibility for each credit. The decision-making responsibility matrix is not intended to exclude any party, rather to emphasize those credits that are most likely to require strong participation by a particular team member.

Case Study

Collaborative Innovation Center Pittsburgh, Pennsylvania

Collaborative Innovation Center at Carnegie Mellon University contains 136,000-sq.ft. of tenant space above a 238-car parking garage in a building that fits into the visual context of the nearby older campus buildings. To reduce both solar gain and energy consumption for cooling, cantilevered concrete slabs provide shading from the sun on the appropriate elevations. A raised floor HVAC system and a daylight dimming system resulted in a building design energy model that measured at 23% better than the ASHRAE 90.1-1999 base case. Tenants are able to manually operate diffusers and thermostats. Operable windows also allow for individual comfort control. The building also features an 8,000-gallon cistern system that supplies all of the water to run a graywater system for the building. A 39.8% reduction in the use of potable water is achieved by gathering the stormwater and by selecting plants that do not need irrigation. Based on cost, 16.7% of the building materials contain recycled content, and more than 90% of the construction waste was diverted from landfills. 41% of the building materials were manufactured within the region and 52% of those materials were harvested locally. The Center was awarded a LEED-CS Gold Rating in December 2005.



Photo courtesy of: Massery Photography

Table 1: EQ Credit Characteristics

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Credit	Significant Change from LEED-NC v2.2					
		Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
EQp1: Minimum IAQ Performance		*			*	
EQp2: Environmental Tobacco Smoke (ETS) Control		*		*	*	
EQc1: Outdoor Air Delivery Monitoring		*			*	
EQc2: Increased Ventilation		*			*	
EQc3: Construction IAQ Management Plan, During Construction			*			*
EQc4.1: Low-Emitting Materials, Adhesives & Sealants	*		*		*	*
EQc4.2: Low-Emitting Materials, Paints & Coatings	*		*		*	*
EQc4.3: Low-Emitting Materials, Carpet Systems	*		*		*	
EQc4.4: Low-Emitting Materials, Composite Wood & Agrifiber	*		*		*	*
EQc5: Indoor Chemical & Pollutant Source Control		*			*	
EQc6: Controllability of Systems, Thermal Comfort		*			*	
EQc7: Thermal Comfort, Design		*			*	
EQc8.1: Daylight & Views, Daylight 75% of Spaces		*			*	
EQc8.2: Daylight & Views, Views for 90% of Spaces		*			*	

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Minimum IAQ Performance

Intent

Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

Requirements

Meet the minimum requirements of Sections 4 through 7 of ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Mechanical ventilation systems shall be designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent.

Naturally ventilated buildings shall comply with ASHRAE 62.1-2004, paragraph 5.1.

Mechanical ventilation systems installed during core and shell construction shall be capable of meeting projected ventilation levels based on anticipated future tenant requirements.

Potential Technologies & Strategies

Design ventilation systems to meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE standard. Balance the impacts of ventilation rates on energy use and indoor air quality to optimize for energy efficiency and occupant health. Use the ASHRAE 62 Users Manual for detailed guidance on meeting the referenced requirements.

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Prerequisite 1					

Required



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Prerequisite 1					

Summary of Referenced Standard

ASHRAE Standard 62.1-2004: Ventilation For Acceptable Indoor Air Quality

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

“The purpose of this standard is to specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects. This standard is intended for regulatory application to new buildings, additions to existing buildings and those changes to existing buildings that are identified in the body of the standard. This standard applies to all indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard. Release of moisture in residential kitchens and bathrooms, locker rooms, and swimming pools is included in the scope of this standard. Additional requirements for laboratory, industrial, and other spaces may be dictated by workplace and other standards, as well as by the processes occurring within the space. This standard considers chemical, physical, and biological contaminants that can affect air quality. Thermal comfort requirements are not included in this standard.” (ASHRAE 62.1-2004)

Note that although ASHRAE Standard 62.1-2004 will be the relevant standard for the vast majority of LEED-CS projects, certain low-rise residential projects pursuing LEED-CS certification may use ASHRAE Standard 62.2-2004 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings to comply with this prerequisite.

Approach and Implementation

Building mechanical and passive ventilation systems seek to ensure that adequate fresh air is available for occupants in the space. Under-ventilated buildings may be stuffy, odorous, uncomfortable and/or unhealthy for occupants. ASHRAE Standard 62.1-2004 establishes minimum requirements for the ventilation air rates in various types of occupied zones and building ventilation systems. The standard takes into account the density of people within an area, the type of activity that is expected to occur in the space, and the nature of the ventilation air delivery system.

Core and Shell Considerations

Core and shell buildings may not have identified the final occupancy count. Projects that do not know the occupancy count must utilize the default occupancy counts provided in Appendix 1. Projects that do know the tenant occupancy must use these numbers as long as the gross square foot per employee is not greater than that in the default occupancy count table.

Often, not only is the occupancy of the building unknown, the distribution of that occupancy is also unknown. Occupancy distribution is necessary for portions of the calculations in ASHRAE 62.1-2004 that determine the percentage of outside air on a system level. For the core and shell project it typically is necessary to determine the system level outside air without the distribution of people. As an example, a typical office building has office and conference room space. The conference rooms require more outdoor air than the offices. If these spaces are all on the same system, the system level outside air must be increased to account for the outside air requirements of the conference rooms. A core and shell building will not know where conference rooms and other densely occupied spaces will be located. For the

sake of the calculations, a distribution of people will have to be assumed.

Strategies

There are three basic methods for ventilating buildings:

- Active Ventilation (i.e., mechanical ventilation)
- Passive Ventilation (i.e., natural ventilation)
- Mixed-mode Ventilation (i.e., both mechanical and natural ventilation)

Mechanically Ventilated Spaces—Ventilation Rate Procedure

For mechanical ventilation systems, ASHRAE Standard 62.1-2004, Section 6, presents procedures for determining the minimum required ventilation rates for various applications, using either the Ventilation Rate Procedure or the Indoor Air Quality Procedure. The Ventilation Rate Procedure is more straightforward to apply and much more common in practice and is the prescribed approach required by EQ Prerequisite 1.

The Ventilation Rate Procedure methodology is found in Section 6.2 of ASHRAE 62.1-2004. The breathing zone outdoor airflow is equal to the sum of the outdoor airflow rate required per person times the

zone population, plus the outdoor airflow rate required per unit area times the zone floor area. The standard's Table 6-1 "Minimum Ventilation Rates in Breathing Zone" provides information by occupancy category to determine both the amount of outdoor air needed to ventilate people-related source contaminants and area-related source contaminants. The people-related sources portion of the outdoor air rate addresses actual occupancy density and activity. The area-related sources portion accounts for background off-gassing from building materials, furniture and materials typically found in that particular occupancy. Finally, the required zone outdoor airflow is the breathing zone outdoor airflow adjusted to reflect the "zone air distribution effectiveness" using adjustment factors in Table 6-2 of the standard. For multiple-zone systems, outdoor air intake flow is adjusted to reflect the "system ventilation efficiency" of the air distribution configuration, using adjustment factors in Table 6-3 of the standard.

Core and Shell projects with multiple-zone systems will need to assume a "system ventilation efficiency." This must reflect the expected occupant distribution. A tenant fit test or sample plan can be used to approximate the occupant distribution and estimate the "system ventilation efficiency." **Table 1** is sample documentation

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Table 1: Sample Summary Calculations Used to Determine Outdoor Air Ventilation Rates – Mechanically Ventilated

Zone Identification			Standard Case: ASHRAE Std 62.1-2004 Verification Rate Procedure									Design Case		
Zone	Occupancy Category	Area (sf)	People Outdoor Air Rate (cfm/person)	Area Outdoor Air Rate (cfm/sf)	Occupant Density (#/1000 sf)	Breathing Zone Outdoor Air Flow Vbz/ (CFM)	Table 6-2 Zone Air Distribution Effectiveness Ez	Zone Outdoor Air Flow Voz/ (CFM)	Table 6-3 System Ventilation Efficiency Ev	Outdoor Air Intake Flow Vot/ (CFM)	Outdoor Air Intake Flow (CFM)	Zone Primary Air Flow Fraction Vpz/ (CFM)	Primary Outdoor Air Fraction Zp = Voz/ Vpz	Meets Standard?
General Office	Office Space	8000	5	0.06	5	680	1.0	680	1.0	680	800	8000	0.09	Y
Training Room	Lecture Classroom	750	7.5	0.06	65	411	1.2	342	0.9	360	400	1400	0.24	Y
Break Room	Conference Meeting	250	5	0.06	50	63	1.0	63	1.0	63	75	500	0.13	Y
Total		9000				1154		1085		1123	1275	9900		Y

Notes: For the general office space air distribution is overhead, hence $E_z = 1$. Outdoor air fraction, $Z_p < 0.15$, hence System Ventilation Efficiency is 1.0. For the training room, air distribution is underfloor, hence $E_z = 1.2$. Outdoor air fraction, $Z_p < 0.25$, hence System Ventilation Efficiency is 0.9. For the break room, air distribution is overhead, hence $E_z = 1$. Outdoor air fraction, $Z_p < 0.15$, hence System Ventilation Efficiency is 1.0.

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based on a reasonable breakdown of spaces in an office building. It is important for project teams to take this into account. Not accounting for spaces with a high occupant density can lead to undersized ventilation systems and can affect a tenant's ability to comply with ASHRAE Standard 62.1-2004 for their own projects.

This prerequisite requires that applicants demonstrate that the delivered minimum zone outdoor airflow for each zone and the outdoor air intake flow for the system meets or exceeds that required by ASHRAE Standard 62.1-2004 for each zone.

Naturally Ventilated Spaces

ASHRAE Standard 62.1-2004 Section 5.1 provides requirements on the location and size of ventilation openings for naturally ventilated buildings. The standard requires that all naturally ventilated spaces shall be permanently open to, and within 25 feet of, operable wall or roof openings and that the operable area be at least 4% of the net occupiable floor area. As appropriate, all other non-ventilation-related requirements (i.e., exhaust for combustion appliances, outdoor air assessment, and outdoor air intakes) in the standard must be met to comply with this prerequisite.

Mixed-Mode Ventilated Spaces

For mixed-mode ventilated spaces, project teams need to meet the minimum ventilation rates required by Chapter 6 of ASHRAE 62.1-2004 regardless of ventilation mode (natural ventilation, mechanical ventilation or both mechanical and natural ventilation).

Calculations

See **Table 1**.

Exemplary Performance

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Templates, which include the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This prerequisite is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document prerequisite compliance using the LEED-CS v2.0 Submittal Templates:

- Provide a design narrative describing the project's ventilation design. Include specific information regarding fresh air intake volumes and any special conditions that affected the project's ventilation design. The narrative should also address any assumptions made about occupant density and "system ventilation effectiveness."

AND

- For Mechanically Ventilated Buildings: confirmation that the project has been designed to meet the minimum requirements of ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality, using the Ventilation Rate Procedure. This should be provided in spreadsheet format similar to **Table 1**.

OR

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- ❑ For Naturally Ventilated Buildings: confirmation that the project has been designed to comply with the requirements for location and size of window openings per ASHRAE Standard 62.1-2004, Section 5.1.

AND

- ❑ For Naturally Ventilated Buildings: provide applicable project drawings to show the naturally ventilated building zones and the operable window areas.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is available to core and shell projects that incorporate into tenant sales or lease agreements requirements for meeting this credit as part of the tenant scope of work. Provide the LEED letter template for the credit pursued indicating the following:

- ❑ 100% of leased square footage complies with credit requirements. Lease or sales agreements may be requested.
- ❑ 100% of the unleased square footage shall comply with the credit requirements when leased. A statement signed by the owner/developer that all leases and/or sales agreements will comply may be requested.

Considerations

Good indoor air quality in buildings may yield improved occupant comfort, well-being and productivity. A key component of maintaining indoor air quality in a green building is providing adequate ventilation. ASHRAE Standard 62.1-2004 describes procedures for avoiding the introduction of contaminants; the criterion includes location of air intakes as they relate to potential outdoor sources of contamination. The standard also outlines general ventilation rates for a variety of building types and occupancy categories.

Because ASHRAE Standard 62.1-2004 has become standard ventilation design

practice for many areas, generally no additional design effort or capital cost will be required to meet this prerequisite. Its successful implementation reduces potential liability regarding indoor air quality issues for architects, builders, owners, building operators and occupants.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org
(404) 636-8400

ASHRAE advances the science of heating, ventilation, air conditioning and refrigeration for the public's benefit through research, standards writing, continuing education and publications.

U.S. Environmental Protection Agency's Indoor Air Quality Website

www.epa.gov/iaq
(800) 438-4318

This site includes a wide variety of tools, publications and links to address IAQ concerns in schools and large buildings.

Definitions

Indoor Air Quality is the nature of air inside the space that affects the health and well-being of building occupants.

Mechanical Ventilation is provided by mechanical powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows (ASHRAE 62.1-2004).

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Natural Ventilation is provided by thermal, wind or diffusion effects through doors, windows or other intentional openings in the building (ASHRAE 62.1-2004).

Ventilation is the process of supplying and removing air to and from a space for the purpose of controlling air contaminant levels, humidity or temperature within the space.

Mixed-mode Ventilation is a ventilation strategy that combines natural ventilation with mechanical ventilation allowing the building to be ventilated either mechanically or naturally and at times both mechanically and naturally simultaneously.

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Prerequisite 2					

Environmental Tobacco Smoke (ETS) Control

Intent

Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to Environmental Tobacco Smoke (ETS).

Requirements

OPTION 1

- Prohibit smoking in the building.
- Locate any exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows.

OR

OPTION 2

- Prohibit smoking in the public areas of the building except in designated smoking areas. Public areas include all common areas that are part of the core and shell that are not tenant spaces. Locate any exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows.
- Locate designated smoking rooms to effectively contain, capture and remove ETS from the building. At a minimum, the smoking room must be directly exhausted to the outdoors with no re-circulation of ETS-containing air to the non-smoking area of the building, and enclosed with impermeable deck-to-deck partitions. With the doors to the smoking room closed, operate exhaust sufficient to create a negative pressure with respect to the adjacent spaces of at least an average of 5 Pa (0.02 inches of water gauge) and with a minimum of 1 Pa (0.004 inches of water gauge).
- Performance of the smoking room differential air pressures shall be verified by conducting 15 minutes of measurement, with a minimum of one measurement every 10 seconds, of the differential pressure in the smoking room with respect to each adjacent area and in each adjacent vertical chase with the doors to the smoking room closed. The testing will be conducted with each space configured for worst case conditions of transport of air from the smoking rooms to adjacent spaces with the smoking rooms' doors closed to the adjacent spaces.

OR

OPTION 3 (For residential buildings only)

- Prohibit smoking in all common areas of the building.
- Locate any exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows opening to common areas.
- Minimize uncontrolled pathways for ETS transfer between individual residential units by sealing penetrations in walls, ceilings and floors in the residential units, and by sealing vertical chases adjacent to the units.
- All doors in the residential units leading to common hallways shall be weather-stripped to minimize air leakage into the hallway.

Required



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- If the common hallways are pressurized with respect to the residential units then doors in the residential units leading to the common hallways need not be weather-stripped provided that the positive differential pressure is demonstrated as in Option 2, considering the residential unit as the smoking room. Acceptable sealing of residential units shall be demonstrated by a blower door test conducted in accordance with ANSI/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization, AND use of the progressive sampling methodology defined in Chapter 4 (Building HVAC Requirements) of the Residential Manual for Compliance with California's 2005 Energy Efficiency Standards (www.energy.ca.gov/title24/residential_manual). Residential units must demonstrate less than 1.25 square inches leakage area per 100 square feet of enclosure area (i.e., sum of all wall, ceiling and floor areas).

Potential Technologies & Strategies

Prohibit smoking in commercial buildings or effectively control the ventilation air in smoking rooms. For residential buildings, prohibit smoking in common areas, design building envelope and systems to minimize ETS transfer among dwelling units.

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Summary of Referenced Standards

ANSI/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization

To purchase this standard go to: www.astm.org

“1.1 This test method covers a standardized technique for measuring air-leakage rates through a building envelope under controlled pressurization and de-pressurization... 1.3 This test method is intended to produce a measure of airtightness of a building envelope...” (ASTM-E779-03)

Residential Manual for Compliance with California’s 2005 Energy Efficiency Standards (For Low Rise Residential Buildings), Chapter 4

www.energy.ca.gov/2005publications/CEC-400-2005-005/chapters_3q/4_Building_HVAC.pdf

“The *Standards* require quality design and construction of HVAC systems and air distribution systems. They also offer compliance credit for the construction of less leaky building envelopes. With the 2005 *Standards*, testing of ducts, refrigerant charge, and airflow was added to the prescriptive requirements (Package D) and is assumed as part of the standard design in performance calculations. Many of the compliance credit options require installer diagnostic testing and certification, and independent diagnostic testing and field verification by a certified Home Energy Rater.” (Residential Manual for Compliance with California’s 2005 Energy Efficiency Standards [For Low Rise Residential Buildings] Chapter 4)

Approach and Implementation

Prohibit smoking in the building. Provide designated smoking areas outside of the building in locations where ETS will not enter the building or ventilation

system. These designated areas should also be located away from concentrations of building occupants or pedestrian traffic. Post information regarding the building’s non-smoking policy for all occupants to read.

If interior smoking areas are designed within the building, separate ventilation systems must be installed, and their effectiveness must be tested to ensure that they are isolated from other, non-smoking portions of the building.

The design criteria and instructions for Options 2 and 3 are detailed in the credit requirements and the referenced standard for Option 3.

Core and Shell Considerations

In many regions of North America, municipal regulations do not allow smoking. However, in areas where this is allowed and the owner does not make a building-wide policy prohibiting smoking in the building, careful consideration must be taken, if a core and shell building chooses to allow tenants the option of a smoking area in their space. Such an area must follow all of the requirements for smoking areas listed in this prerequisite. It is important to protect other tenants from the ETS and therefore extra care must be taken to ensure that the smoking area functions as intended. No air from the smoking area is allowed to return back to a common HVAC system. The building will have to accommodate a separate exhaust system from the smoking area. Providing for a separate exhaust system, that is not part of the original design can prove difficult. The space for mechanical equipment and chases in many buildings is so efficiently utilized that extra space for such systems will be at a premium.

Calculations

There are no calculations associated with this credit.

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Exemplary Performance

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Templates, which include the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This prerequisite is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and information is required to document prerequisite compliance using the LEED-CS v2.0 Submittal Templates:

- Confirm that the project has met the requirements for the appropriate project category: Non-Smoking Building; Building with Designated Smoking Rooms; or Residential Project.
- For buildings with interior smoking rooms or for residential projects, provide appropriate copies of construction drawings to document the location of the smoking rooms, designed area separations, and dedicated ventilation systems.
- An optional narrative may be provided to further describe the testing proto-

cols/results and compliance methods implemented by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Considerations

The relationship between smoking and various health risks, including lung disease, cancer and heart disease, has been well documented. A strong link between Environmental Tobacco Smoke (ETS) or “secondhand smoke” and health risks has also been demonstrated.

The most effective way to avoid health problems associated with ETS is to prohibit smoking indoors. If this cannot be accomplished, indoor smoking areas should be isolated from non-smoking areas and have separate ventilation systems to avoid the introduction of tobacco smoke contaminants to non-smoking areas.

Environmental Issues

Separate smoking areas occupy space in the building and may result in a larger building, additional material use and increased energy for ventilation. However, these environmental impacts can be offset by building occupants who are more comfortable, have higher productivity rates, and have lower absenteeism and illnesses.

Economic Issues

Separate smoking areas add to the design and construction costs of most projects. Maintenance of designated smoking areas also adds to lease and operating costs. Prohibition of indoor smoking can increase the useful life of interior fixtures and furnishings. Smoking within a building contaminates indoor air and can cause occupant reactions ranging from irritation and illness to decreased productivity. These problems increase expenses and

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liability for building owners, tenants, operators and insurance companies.

Core and shell buildings that choose to allow tenants to build smoking areas may need to oversize mechanical rooms and chases for this potential.

Community Issues

Air is a community natural resource, and promoting clean air benefits everyone. Strict no-smoking policies improve the health of the community as a whole, resulting in lower health care and insurance costs.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

ANSI/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization

www.astm.org

Standard may be purchased at this website.

Home Energy Rating Systems (HERS) Required Verification And Diagnostic Testing, California Low Rise Residential Alternative Calculation Method Approval Manual

www.energy.ca.gov/2005publications/CEC-400-2005-005/chapters_3q/4_Building_HVAC.pdf

What You Can Do About Secondhand Smoke as Parents, Decision Makers, and Building Occupants

U.S. Environmental Protection Agency

www.epa.gov/smokefree/pubs/etsbro.html

(800) 438-4318

An EPA document on the effects of ETS and measures to reduce human exposure to it.

Setting the Record Straight: Secondhand Smoke Is a Preventable Health Risk

U.S. Environmental Protection Agency

www.epa.gov/smokefree/pubs/strsfs.html

An EPA document with a discussion of laboratory research on ETS and federal legislation aimed at curbing ETS problems.

Print Media

The Chemistry of Environmental Tobacco Smoke: Composition and Measurement, Second Edition by R.A. Jenkins, B.A. Tomkins, et al., CRC Press & Lewis Publishers, 2000.

The Smoke-Free Guide: How to Eliminate Tobacco Smoke from Your Environment by Arlene Galloway, Gordon Soules Book Publishers, 1988.

Definitions

Environmental Tobacco Smoke (ETS), or secondhand smoke, consists of airborne particles emitted from the burning end of cigarettes, pipes, and cigars, and exhaled by smokers. These particles contain about 4,000 different compounds, up to 40 of which are known to cause cancer.

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Prerequisite 2					

Outdoor Air Delivery Monitoring

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Credit 1					

Intent

Provide capacity for ventilation system monitoring to help sustain occupant comfort and well-being.

Requirements

Install permanent monitoring systems that provide feedback on ventilation system performance to ensure that ventilation systems maintain design minimum ventilation requirements. Configure all monitoring equipment to generate an alarm when the conditions vary by 10% or more from setpoint, via either a building automation system alarm to the building operator or via a visual or audible alert to the building occupants.

FOR MECHANICALLY VENTILATED SPACES

- ❑ For each mechanical ventilation system, provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor airflow rate with an accuracy of plus or minus 15% of the design minimum outdoor air rate, as defined by ASHRAE 62.1-2004.

FOR NATURALLY VENTILATED SPACES

Monitor CO₂ concentrations within all naturally ventilated spaces. CO₂ monitoring shall be located within the room between 3 feet and 6 feet above the floor. One CO₂ sensor may be used to represent multiple spaces if the natural ventilation design uses passive stack(s) or other means to induce airflow through those spaces equally and simultaneously without intervention by building occupants.

Potential Technologies & Strategies

Install carbon dioxide and airflow measurement equipment and feed the information to the HVAC system and/or Building Automation System (BAS) to trigger corrective action, if applicable. If such automatic controls are not feasible with the building systems, use the measurement equipment to trigger alarms that inform building operators or occupants of a possible deficiency in outdoor air delivery.

Installation of CO₂ sensors in tenant spaces is not required during Core and Shell construction and tenants are not required to install CO₂ monitors, however they should be made aware of the capability of the core and shell system to monitor CO₂. The core and shell systems must be designed with the capacity for CO₂ monitoring. This entails a building automation system that can be expanded to include future tenant CO₂ points.

1 point



Can assist tenants in certification under LEED for Commercial Interiors

SS	WE	EA	MR	EQ	ID
Credit 1					

Summary of Referenced Standard

ASHRAE Standard 62.1-2004: Ventilation For Acceptable Indoor Air Quality

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

“The purpose of this standard is to specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects. This standard is intended for regulatory application to new buildings, additions to existing buildings and those changes to existing buildings that are identified in the body of the standard. This standard applies to all indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard. Release of moisture in residential kitchens and bathrooms, locker rooms, and swimming pools is included in the scope of this standard. Additional requirements for laboratory, industrial, and other spaces may be dictated by workplace and other standards, as well as by the processes occurring within the space. This standard considers chemical, physical, and biological contaminants that can affect air quality. Thermal comfort requirements are not included in this standard.” (ASHRAE 62.1-2004)

Note that although ASHRAE Standard 62.1-2004 will be the relevant standard for the vast majority of LEED-CS projects, certain low-rise residential projects pursuing LEED-CS certification may use ASHRAE Standard 62.2-2004 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings to comply with this prerequisite.

Approach and Implementation

Building HVAC systems are designed to flush out indoor airborne contaminants by exhausting old air and replacing it with fresh outdoor air. The rate of ventilation air exchange is generally determined in the design phase based on space density and type of occupancy. Many conventional ventilation systems do not directly measure the amount of outdoor air delivered. Implementation of the following strategies is recommended to achieve this credit.

Outdoor Air Flow Monitoring

Air flow monitoring of the outdoor air rate validates that the HVAC equipment is delivering the required ventilation rate. Air balance control methodologies, such as fan tracking and measuring building-pressurization based strategies, do not directly determine that appropriate ventilation air is being provided and do not satisfy the credit requirement. The ventilation rate can be measured at the outdoor air intake to an air distribution system using a variety of airflow devices including Pitot tubes, Venturi meters and rotating vane anemometers. Ventilation rate for a particular HVAC system can also be accurately determined from a mass balance calculation if both supply air flow and return air flow are directly measured with air flow monitoring devices. To satisfy the requirements of this credit, the measurement devices must detect when the system is 15% below the design minimum outdoor air rate. When the ventilation system fails to provide the required levels of fresh air, the monitoring system should be configured to deliver a visible or audible alert to the system operator. This alert will indicate to the system operator that operational adjustments may be necessary.

The minimum outdoor air rate may change based on the design and modes of the HVAC system. Constant volume

SS	WE	EA	MR	EQ	ID
Credit 1					

systems, with steady-state design occupancy conditions usually have different outdoor air rates for weekdays and nighttime or off-peak conditions. In variable-air-volume (VAV) systems, the rate of outdoor air needs to stay above the design minimum even when the supply air flow is reduced due to reduced thermal load conditions.

CO₂ Monitoring

The effectiveness of the ventilation system to deliver the needed outdoor air can also be monitored using carbon dioxide (CO₂) monitors. In demand controlled ventilation (DCV) systems, where the outdoor air rate supplied to an area is based on readings taken by one or more CO₂ monitors located within the occupied spaces, the system-wide outdoor air rate will fluctuate. A DCV system is a typical energy conservation strategy for large spaces with variable occupancy, such as a large lecture hall where the number of people and times of use varies significantly. In this type of operation, the monitoring system confirms that the space—the lecture hall—is receiving adequate outdoor air for the current occupancy, and that the central system adjusts the ventilation rate to match the changing requirement.

CO₂ sensors, when properly placed, are a practical means of confirming that a ventilation system is functioning properly. There are two typical system configurations that generally meet the requirements of this credit.

One approach utilizes CO₂ sensors that use measured concentration to provide an alert. An indoor concentration of 1000 ppm has commonly been used in the past as the setpoint for the alarm, but a higher alarm concentration may be appropriate when the design complies with Standard 62.1-2004, since the effective ventilation rate per person has been reduced significantly for some zones.

ASHRAE 62.1-2004 Users Manual Appendix A provides a further discussion on CO₂ sensors including demand control ventilation.

CO₂ monitoring locations should be selected so that they provide representative readings of the CO₂ concentrations in occupied spaces. Providing multiple CO₂ monitoring stations throughout occupied spaces will provide better information and control than providing a single CO₂ monitor for the entire system. A single CO₂ monitor, typically installed in the return air duct, is less expensive and more straightforward to implement than providing multiple sensors, but may not yield information that identifies areas within the building that are under-ventilated.

Ventilation Air Flow Monitoring

For mechanically-ventilated spaces this LEED-CS credit requires that the outdoor ventilation rate be directly measured and compared against the minimum required ventilation rate. Typically this will be provided by air flow monitoring stations located in the outdoor air intakes of each central HVAC air distribution system. The direct outdoor airflow measurement device must be capable of measuring the outdoor airflow rate at all expected system operating conditions within an accuracy of plus or minus 15% of the design minimum outdoor air rate.

CO₂ Monitoring in Naturally Ventilated Spaces

For naturally ventilated buildings, monitoring CO₂ levels in the occupied space provides feedback to building occupants and operators, so that they can make operational adjustments, such as opening windows, if the space becomes under ventilated. The CO₂ monitors in naturally ventilated spaces should be mounted in the vertical breathing zone between 3 and 6 feet above the floor.

SS	WE	EA	MR	EQ	ID
Credit 1					

Operations & Maintenance

As part of the system commissioning, project teams should confirm that the outdoor air delivery monitoring system is calibrated, and that the appropriate setpoints and control sequences have been implemented. Provide the building owner, maintenance personnel and occupants with the information needed to understand, maintain and respond to the monitoring system. Maintenance personnel should make inspection of CO₂ monitors and airflow monitoring stations part of routine O&M and preventive maintenance activities. Sensors should be recalibrated based on the manufacturer's requirements. It is recommended to use CO₂ sensors that require recalibration no less than every 5 years. If a CO₂ monitor is allowed to fall out of calibration it may indicate that indoor CO₂ concentrations are lower or higher than they actually are, leading to under- or over-ventilation of the space.

A permanent ventilation monitoring system assists in detecting indoor air quality problems quickly so that corrective action can be taken. Under-ventilation of a space can lead to unsatisfactory indoor environmental conditions and occupant discomfort. Over-ventilation of a space may needlessly increase HVAC energy costs.

Building Type

Air flow and CO₂ monitoring systems can be applied to any building or HVAC system type—including both mechanically and naturally ventilated buildings. In addition to ventilation alarms, such monitors can provide building operators and automated control systems (i.e., demand control ventilation) with information that allows for operational adjustments, such as increasing or decreasing intake airflow rates.

For naturally ventilated buildings and spaces served by HVAC systems that do not allow for active control of ventila-

tion rates, CO₂ monitors in the occupied spaces can provide building occupants and operators with useful information that allows for operational adjustments, such as opening windows or adjusting fixed ventilation rates, if the CO₂ monitors indicate that the space is under ventilated.

Core and Shell Considerations

Providing the required amount of outside air to tenant spaces is a very important consideration in core and shell buildings. Sufficient outside air must be provided at all times to the tenant spaces. Airflow monitoring stations allow the outdoor air quantities to be measured and tracked. This helps to ensure that proper ventilation is being provided.

Project teams may want to include measures to allow tenants to monitor the CO₂ in their spaces. The control system can be specified to include expansion capability, so that tenants can use CO₂ monitors. This gives tenants the opportunity to earn points in the LEED-CI rating system.

Calculations

There are no calculations required for this credit.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Templates, which include the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member

- ❑ Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

by the owner/developer that all leases and/or sales agreements will comply may be requested.

SS	WE	EA	MR	EQ	ID
Credit 1					

Certification Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- ❑ Confirm the type of ventilation system and installed controls.
- ❑ Provide a design narrative describing the project's ventilation design and CO₂ monitoring system (for naturally ventilated buildings). Include specific information regarding location and quantity of installed monitors, operational parameters and setpoints.
- ❑ Provide copies of the applicable project drawings to document the location and type of installed sensors. Drawings should also show natural ventilation components (operable windows, air intakes, etc.) as applicable.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is available to core and shell projects that incorporate into tenant sales or lease agreements requirements for compliance with the credit as part of the tenant scope of work. Provide the LEED letter template for the credit pursued indicating the following:

- ❑ 100% of leased square footage complies with credit requirements. Lease or sales agreements may be requested.
- ❑ 100% of the unleased square footage shall comply with the credit requirements when leased. A statement signed

Considerations

Cost Issues

CO₂ and ventilation rate monitoring systems increase initial construction costs compared to ventilation systems without such monitoring capabilities. Capital costs and annual costs for air flow monitoring equipment maintenance and calibration procedures may be offset by reduced absenteeism, increased occupant productivity and/or reduced HVAC energy use.

Regional Issues

Ambient outdoor CO₂ concentrations may fluctuate somewhat based on local and regional factors, between approximately 300 and 500 ppm. The time-of-day fluctuations near major congested highways and annual fluctuations, if any, should also be considered. High ambient CO₂ concentrations are typically an indicator of combustion or other contaminant sources. Lower ventilation rates may yield a sense of stuffiness or general dissatisfaction with IAQ.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

ASHRAE 62.1-2004 Users Manual Appendix A

www.ashrae.org

Provides information on CO₂ sensors including demand control ventilation.

SS	WE	EA	MR	EQ	ID
Credit 1					

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org
(404) 636-8400

ASHRAE advances the science of heating, ventilation, air conditioning and refrigeration for the public's benefit through research, standards writing, continuing education and publications.

Building Air Quality: A Guide for Building Owners and Facility Managers

www.epa.gov/iaq/largebldgs/baqtoc.html
(800) 438-4318

An EPA publication on IAQ sources in buildings and methods to prevent and resolve IAQ problems.

Print Media

Air Handling Systems Design by Tseng-Yao Sun, McGraw Hill, 1992.

ASHRAE Standard 55-2004: Thermal Environmental Conditions for Human Occupancy, ASHRAE, 2004

ASHRAE Standard 62.1-2004: Ventilation for Acceptable Indoor Air Quality, ASHRAE, 2004

ASHRAE Standard 62.2-2004: Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings, ASHRAE, 2004

ASTM D 6245-1998: Standard Guide for Using Indoor Carbon Dioxide Concentrations to Value Indoor Air Quality and Ventilation, ASTM, 1998

Efficient Building Design Series, Volume 2: Heating, Ventilating, and Air Conditioning by J. Trost and Frederick Trost, Prentice Hall, 1998.

Definitions

CO₂ is carbon dioxide.

Mechanical Ventilation is ventilation provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows (ASHRAE 62.1-2004).

Natural Ventilation is ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building (ASHRAE 62.1-2004).

ppm stands for parts per million

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity or temperature within the space (ASHRAE 62.1-2004).

Increased Ventilation

SS	WE	EA	MR	EQ	ID
Credit 2					

Intent

Provide additional outdoor air ventilation to improve indoor air quality for improved occupant comfort, well-being and productivity.

Requirements

FOR MECHANICALLY VENTILATED SPACES

- ❑ Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2004 as determined by EQ Prerequisite 1.

FOR NATURALLY VENTILATED SPACES

Design natural ventilation systems for occupied spaces to meet the recommendations set forth in the Carbon Trust Good Practice Guide 237 [1998]. Determine that natural ventilation is an effective strategy for the project by following the flow diagram process shown in Figure 1.18 of the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 10: 2005, Natural ventilation in non-domestic buildings.

AND

- ❑ Use diagrams and calculations to show that the design of the natural ventilation systems meets the recommendations set forth in the CIBSE Applications Manual 10: 2005, Natural ventilation in non-domestic buildings.

OR

- ❑ Use a macroscopic, multi-zone, analytic model to predict that room-by-room airflows will effectively naturally ventilate, defined as providing the minimum ventilation rates required by ASHRAE 62.1-2004 Chapter 6, for at least 90% of occupied spaces.
- ❑ The core and shell buildings that are designed to be naturally ventilated must provide the capability for the tenant build-out to meet the requirements of this credit.

Potential Technologies & Strategies

For Mechanically Ventilated Spaces: use heat recovery, where appropriate, to minimize the additional energy consumption associated with higher ventilation rates.

For Naturally Ventilated Spaces: follow the eight design steps described in the Carbon Trust Good Practice Guide 237: 1) Develop design requirements, 2) Plan airflow paths, 3) Identify building uses and features that might require special attention, 4) Determine ventilation requirements, 5) Estimate external driving pressures, 6) Select types of ventilation devices, 7) Size ventilation devices, 8) Analyze the design. Use public domain software such as NIST's CONTAM, Multizone Modeling Software, along with LoopDA, Natural Ventilation Sizing Tool, to analytically predict room-by-room airflows.

1 point



Can assist tenants in certification under LEED for Commercial Interiors

SS	WE	EA	MR	EQ	ID
Credit 2					

Summary of Referenced Standards

ASHRAE Standard 62.1-2004: Ventilation For Acceptable Indoor Air Quality

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

“The purpose of this standard is to specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects. This standard is intended for regulatory application to new buildings, additions to existing buildings, and those changes to existing buildings that are identified in the body of the standard. This standard applies to all indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard. Release of moisture in residential kitchens and bathrooms, locker rooms, and swimming pools is included in the scope of this standard. Additional requirements for laboratory, industrial, and other spaces may be dictated by workplace and other standards, as well as by the processes occurring within the space. This standard considers chemical, physical, and biological contaminants that can affect air quality. Thermal comfort requirements are not included in this standard.” (ASHRAE 62.1-2004)

Note that although ASHRAE Standard 62.1-2004 will be the relevant standard for the vast majority of LEED-CS projects, certain low-rise residential projects pursuing LEED-CS certification may use ASHRAE Standard 62.2-2004 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings to comply with this credit.

The Carbon Trust Good Practice Guide 237—Natural ventilation in non-domestic buildings—a guide for designers; developers and owners (1998)

<http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GPG237>

“Carefully designed, naturally ventilated buildings can be cheaper to construct, maintain and operate than more heavily serviced equivalents. Occupants generally prefer windows that can be opened, and natural light, both of which are features of well designed, naturally ventilated buildings. The Guide summarizes the benefits of natural ventilation and considers the commercial implications, illustrating the issues by means of case studies.” (The Carbon Trust)

CIBSE Applications Manual 10: 2005, Natural ventilation in non-domestic buildings.

www.cibse.org

“This publication is a major revision of the Applications Manual (AM) first published in 1997. At that time, there was a significant expansion of interest in the application of engineered natural ventilation to the design of non-domestic buildings. The original AM10 sought to capture the state of knowledge as it existed in the mid-90s and present it in a form suited to the needs of every member of the design team. Some 10 years on from the time when the initial manual was conceived, the state of knowledge has increased, and experience in the design and operation of naturally ventilated buildings has grown. This revision of AM10 is therefore a timely opportunity to update and enhance the guidance offered to designers and users of naturally ventilated buildings.” (CIBSE)

Approach and Implementation

Approach and Implementation

A green building should provide its occupants with superior indoor air quality

SS	WE	EA	MR	EQ	ID
Credit 2					

to support their health, comfort and well-being. A key component for maintaining superior indoor air quality is providing adequate ventilation rates. Under-ventilated buildings may be stuffy, odorous, uncomfortable and/or unhealthy for occupants.

Building ventilation systems, including both active HVAC systems and natural ventilation systems, are designed and installed to introduce fresh outside air into the building while exhausting an equal amount of building air. HVAC systems typically serve other functions as well, including providing thermal comfort for occupants. Building conditioning systems that provide enhanced ventilation air, as efficiently and effectively as possible, will help to maintain a high standard of indoor air quality in the building.

The requirement for this credit is a 30% increase in ventilation rates beyond the amounts required by ASHRAE 62.1-2004 in office buildings at the breathing zone. The ASHRAE 62.1-2004 rates are approximately 15% to 20% lower than the ASHRAE 62.1-2001 rates. The threshold for this credit was developed based on documented research demonstrating indoor air quality benefits from ventilation rates in the 25 cfm/person range. To achieve 25 cfm/person, the increase would be closer to 50%. 30% was chosen as a compromise between indoor air quality and energy efficiency.

Core and Shell Considerations

Core and shell buildings may not know the final occupancy count. Core and shell projects must utilize the default occupancy counts provided in Appendix 1. Projects that do know the tenant occupancy must use these numbers as long as the gross square foot per employee is not greater than that in the default occupancy count table. Other numbers can be used if justification is provided.

Planning & Design Phase

Most projects decide early on whether to have a mechanical ventilation system, a passive ventilation system, or a combination of both. This decision may be influenced by the building size and type, as well as climatic, economic and organizational influences. **Figure 1** from CIBSE AM10 provides a decision diagram to aid in making a knowledgeable evaluation. In addition to these considerations, project teams considering natural ventilation should evaluate site conditions and building design. Potential IAQ problems might result from heavy traffic, nearby polluting industries and neighboring waste management sites.

For mechanical ventilation, the design and operating setpoints of the HVAC system will be the primary influence on ventilation rates in the building. Building owners and designers should determine if increasing ventilation rates beyond ASHRAE Standard 62.1-2004 requirements is a good idea for their facility. The HVAC design and sizing should account for increased ventilation rates if this strategy is applied.

Occupants generally take a primary role in managing ventilation conditions in naturally ventilated buildings by opening and closing windows as necessary and appropriate. Naturally ventilated buildings generally have somewhat more variable ventilation rates than actively conditioned buildings, whose systems are often designed to maintain no less than minimum ventilation requirements through all periods of occupancy.

Strategies

There are three basic methods for ventilating buildings:

- Active Ventilation (i.e., mechanical ventilation)
- Passive Ventilation (i.e., natural ventilation)

6-1 “Minimum Ventilation Rates in Breathing Zone” provides information by occupancy category to determine both the amount of outdoor air needed to ventilate people-related source contaminants and area-related source contaminants. The people-related sources portion of the outdoor air rate addresses actual occupancy density and activity. The area-related sources portion accounts for background off-gassing from building materials, furniture and materials typically found in that particular occupancy. Finally, the required zone outdoor airflow is the breathing zone outdoor airflow adjusted to reflect the “zone air distribution effectiveness” using adjustment factors in Table 6-2 of the Standard. For multiple-zone systems, outdoor air intake flow is adjusted to reflect the “system ventilation efficiency” for the air distribution configuration, using adjustment factors in Table 6-3 of the Standard.

Core and shell projects with multiple-zone systems will need to assume a “system ventilation efficiency.” This must reflect the expected occupant distribution. A tenant fit test or sample plan can be used to approximate the occupant distribution and estimate the “system ventilation efficiency.” It is important for project teams to take this into account. Not accounting for spaces with a high occupant density

can lead to undersized ventilation systems and can affect a tenant’s ability to comply with ASHRAE Standard 62.1-2004 for their own projects.

This LEED-CS credit requires that applicants demonstrate that the delivered minimum zone outdoor airflow is at least 30% higher than the minimum airflow required by ASHRAE Standard 62.1-2004 for each zone. **Table 1** shows how the sample space used in EQ Prerequisite 1 has attained the 30% increase.

Naturally Ventilated Spaces

Project teams electing natural ventilation have two primary means of demonstrating credit compliance:

- The compliance path found in Chapter 2 of The CIBSE Applications Manual 10 (AM10)

OR

- Documentation using a macroscopic, multi-zone, analytic model that predicts room-by-room outdoor air flow rates

Those using the CIBSE AM10 (see **Figure 1**) begin by establishing the required flow rates through each space. There is an acceptable average rate needed for IAQ and thermal comfort; increasing this rate results in wasted energy during the heating seasons. There is also additional

Table 1: ASHRAE Std 62.1-2004 Ventilation Rate Procedure

Zone Identification			Standard Case: ASHRAE Std 62.1-2004 Verification Rate Procedure									Design Case		
Zone	Occupancy Category	Area (sf)	People Outdoor Air Rate (cfm/person)	Table 6-1 Area Outdoor Air Rate (cfm/sf)	Occupant Density (#/1000 sf)	Breathing Zone Outdoor Air Flow Vbz (CFM)	Table 6-2 Zone Air Distribution Effectiveness Ez	Zone Outdoor Air Flow Voz (CFM)	Table 6-3 System Ventilation Efficiency Ev	Outdoor Air Intake Flow Vot (CFM)	Outdoor Air Intake Flow (CFM)	Zone Primary Air Flow Fraction Vpz (CFM)	Primary Outdoor Air Fraction Zp = Voz/Vpz	% Increase Over Standard
General Office	Office Space	8000	5	0.06	5	680	1.0	680	1.0	680	900	8000	0.09	32%
Training Room	Lecture Classroom	750	7.5	0.06	65	411	1.2	342	0.9	380	500	1400	0.24	32%
Break Room	Conference Meeting	250	5	0.06	50	63	1.0	63	1.0	63	85	500	0.13	36%
Total		9000				1154		1085		1123	1485	9900		32%

Notes: For the general office space air distribution is overhead, hence Ez = 1. Outdoor air fraction, Zp, < 0.15, hence System Ventilation Efficiency is 1.0. For the training room, air distribution is underfloor, hence Ez = 1.2. Outdoor air fraction, Zp < 0.25, hence System Ventilation Efficiency is 0.9. For the break room, air distribution is overhead, hence Ez = 1. Outdoor air fraction, Zp, < 0.15, hence System Ventilation Efficiency is 1.0.

SS	WE	EA	MR	EQ	ID
Credit 2					

ventilation needed for the summer cooling requirements.

CIBSE AM10 lists several natural ventilation analysis methods, either using a separate manual or simulation software. Project teams should confirm their choice with justification. Submittals will need to include a narrative that provides information on the building, its orientation and the glazing ratios. Include a summary of the internal heat gains and weather conditions. Explain the ventilation strategy, including the airflow paths, the rates planned for different operational periods during the day and night, the peak internal temperatures, and means of shading for summer solar gains. Provide sample calculations on the determination of opening size for operable windows, trickle vents and louvers. Finally, include the calculations for the driving pressure showing the effects of both wind and stack-induced pressure differentials.

Project teams using a macroscopic, multi-zone, analytic model that predicts room-by-room air flow rates will need to provide a narrative including the same information listed above. They will also need to demonstrate that 90% of the occupied areas are effectively ventilated, that is to provide minimum ventilation rates required by ASHRAE 62.1-2004, Chapter 6, by natural ventilation. Room-by-room outdoor airflow rates predicted by the analysis should also be provided.

Calculations

For mechanical ventilation systems, project teams should prepare calculations to demonstrate that the design ventilation rates for each zone are at least 30% above the minimum rates required by the Ventilation Rate Procedure of ASHRAE 62.1-2004. This calculation should take the form of a table or spreadsheet similar to **Table 1**. The same calculation may be used to document both EQ Prerequisite 1 and EQ Credit 2.

If this credit is pursued, the design ventilation rates, at least 30% higher than standard ventilation rates, should be incorporated into the energy calculations in EA Credit 1. Depending on the system design and climatic factors, increased ventilation may reduce the calculated and actual energy performance of the building.

For naturally ventilated spaces, project teams should provide sample calculations demonstrating how opening size for operable windows, trickle vents and louvers were determined in accordance with CIBSE AM10 and The Carbon Trust Good Practice Guide 237 (see **Figure 1**).

For naturally ventilated spaces, project teams using a macroscopic, multi-zone, analytic model that predicts room-by-room air flow rates will need to provide the room-by-room outdoor airflow rates predicted by the analysis and a comparison to minimum ventilation rates required by ASHRAE Standard 62.1-2004, Chapter 6.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Templates, which include the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the Design Submittal.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

Mechanically Ventilated Buildings

- Confirm that the breathing zone ventilation rates in all occupied spaces have been designed to exceed the minimum rates required by ASHRAE Standard 62.1-2004 or the applicable local code, whichever is more stringent, by a minimum of 30%. This should be provided in a spreadsheet format similar to **Table 1**.
- Provide a design narrative describing the project's ventilation system design. Include specific information regarding the fresh air intake volume for each specific occupied zone to demonstrate that the design exceeds the referenced standard or the applicable local code, whichever is more stringent, by at least 30%. The narrative should also address any assumptions made about occupant density and "system ventilation effectiveness."

Naturally Ventilated Buildings

- Confirm that the natural ventilation system has been designed to meet the recommendations set forth in the Carbon Trust "Good Practice Guide 237" (1988).
- Provide a design narrative describing the design method (CIBSE Method/Analytic Model) utilized in determining the natural ventilation design for the project. Provide specific information regarding calculation methodol-

ogy and/or model results to demonstrate that the ventilation design complies with the referenced standards.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is available to core and shell projects that incorporate into tenant sales or lease agreements language that requires compliance with this credit as part of the tenant scope of work. Provide the LEED letter template for the credit pursued indicating the following:

- 100% of leased square footage complies with credit requirements. Lease or sales agreements may be requested.
- 100% of the unleased square footage shall comply with the credit requirements when leased. A statement signed by the owner/developer that all leases and/or sales agreements will comply may be requested.

Considerations

Cost Issues

Increasing ventilation rates by 30% beyond ASHRAE Standard 62.1-2004 will yield higher HVAC energy costs and potentially greater HVAC capacity than associated with the ventilation rates established in the standard. This increase in HVAC capacity and energy use will be more pronounced in extreme climates than in mild, temperate climates. Some projects may choose to increase the outdoor air rate, and accept higher HVAC equipment and energy costs, because research indicates that the resulting indoor air quality is associated with improved employee health, welfare, well-being and productivity. For core and shell buildings this may result in improved tenant attraction and retention.

While a naturally ventilated building may have less equipment than a comparable mechanically ventilated building, natural ventilation designs may require additional

SS	WE	EA	MR	EQ	ID
Credit 2					

SS	WE	EA	MR	EQ	ID
Credit 2					

costs for operable windows, increased thermal mass, and other architectural elements which allow for passive ventilation and space conditioning. Energy and maintenance costs of naturally ventilated buildings tend to be lower than for comparable mechanically ventilated spaces.

Regional Issues

Additional ventilation is more practical for mild climates, where increasing ventilation rates beyond the ASHRAE 62.1-2004 minimum rates will not have as great an impact on HVAC systems capacity and energy consumption as in hot, humid or cold climates. Natural ventilation and passive conditioning approaches are also more typical in mild and temperate climates, although there are precedents for passively conditioned buildings in all climates. There may be variable conditions in naturally ventilated buildings, but occupants are satisfied because they control their environment.

Synergies and Trade-Offs

In addition to designing the HVAC systems properly and selecting appropriate building materials, increasing ventilation rates beyond standard practice may be one strategy to provide superior indoor air quality. Managing indoor air quality concerns during construction and operations is also appropriate for many green building projects.

For mechanically ventilated and air-conditioned buildings, increasing ventilation rates will require somewhat larger HVAC system capacity and greater energy use adding to both capital and operational costs. Natural ventilation systems can provide increased ventilation rates, good indoor air quality, and occupant control over thermal comfort and ventilation via operable windows while potentially reducing operating costs compared to mechanical ventilation systems.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

ASHRAE Standard 62.1-2004: Ventilation For Acceptable Indoor Air Quality

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

The Carbon Trust Good Practice Guide 237—Natural ventilation in non-domestic buildings—a guide for designers; developers and owners (1998)

www.thecarbontrust.co.uk

CIBSE Applications Manual 10: 2005, Natural ventilation in non-domestic buildings

www.cibse.org

“This publication is a major revision of the Applications Manual (AM) first published in 1997. At that time, there was a significant expansion of interest in the application of engineered natural ventilation to the design of non-domestic buildings. The original AM10 sought to capture the state of knowledge as it existed in the mid-90s and present it in a form suited to the needs of every member of the design team. Some 10 years on from the time when the initial manual was conceived, the state of knowledge has increased, and experience in the design and operation of naturally ventilated buildings has grown. This revision of AM10 is therefore a timely opportunity to update and enhance the guidance offered to designers and users of naturally ventilated buildings.” (CIBSE)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org
(404) 636-8400

ASHRAE advances the science of heating, ventilation, air conditioning and refrigeration for the public's benefit through research, standards writing, continuing education and publications. To purchase ASHRAE standards and guidelines, visit the bookstore on the ASHRAE website and search for the desired publication.

Building Assessment, Survey and Evaluation Study

U.S. Environmental Protection Agency
www.epa.gov/iaq/largebldgs/base_page.htm

Building Air Quality Action Plan

U.S. Environmental Protection Agency
www.epa.gov/iaq/largebldgs/actionpl.html

The Chartered Institution of Building Services Engineers (CIBSE)

www.cibse.org

This organization, located in London, on its own and in collaboration with other entities, publishes a full series of guides on the topic of ventilation, including natural ventilation.

Definitions

Air Conditioning is the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness and distribution (ASHRAE 62.1-2004).

Breathing Zone is the region within an occupied space between planes 3 and 6 ft. above the floor and more than 2 ft. from the walls or fixed air-conditioning equipment.

Conditioned Space is that part of a building that is heated or cooled, or both, for the comfort of occupants (ASHRAE 62.1-2004).

Contaminant is an unwanted airborne constituent that may reduce acceptability of the air (ASHRAE 62.1-2004).

Exfiltration is uncontrolled outward air leakage from conditioned spaces through unintentional openings in ceiling, floors and walls to unconditioned spaces or the outdoors caused by pressure differences across these openings due to wind, inside-outside temperature differences (stack effect), and imbalances between supply and exhaust airflow rates (ASHRAE 62.1-2004).

Exhaust Air is the air removed from a space and discharged to outside the building by means of mechanical or natural ventilation systems.

Infiltration is uncontrolled inward air leakage to conditioned spaces through unintentional openings in ceilings, floors and walls from unconditioned spaces or the outdoors caused by the same pressure differences that induce exfiltration (ASHRAE 62.1-2004).

Makeup Air is any combination of outdoor and transfer air intended to replace exhaust air and exfiltration (ASHRAE 62.1-2004).

Mechanical Ventilation is ventilation provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows (ASHRAE 62.1-2004).

Natural Ventilation is ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building (ASHRAE 62.1-2004).

Outdoor Air is the ambient air that enters a building through a ventilation system,

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through intentional openings for natural ventilation, or by infiltration (ASHRAE 62.1-2004).

Recirculated Air is the air removed from a space and reused as supply air (ASHRAE 62.1-2004).

Return Air is the air removed from a space to be then recirculated or exhausted (ASHRAE 62.1-2004).

Supply Air is the air delivered by mechanical or natural ventilation to a space, composed of any combination of outdoor air, recirculated air, or transfer air (ASHRAE 62.1-2004).

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Construction IAQ Management Plan

During Construction

Intent

Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

Requirements

Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of the building as follows:

- During construction meet or exceed the recommended Control Measures of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 1995, Chapter 3.
- Protect stored on-site or installed absorptive materials from moisture damage.
- If permanently installed air handlers are used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 shall be used at each return air grille, as determined by ASHRAE 52.2-1999. Replace all filtration media immediately prior to occupancy.

Potential Technologies & Strategies

Adopt an IAQ management plan to protect the HVAC system during construction, control pollutant sources and interrupt contamination pathways. Sequence the installation of materials to avoid contamination of absorptive materials such as insulation, carpeting, ceiling tile and gypsum wallboard. Coordinate with EQ Credit 5 to determine the appropriate specifications and schedules for filtration media.

If possible, avoid using permanently installed air handlers for temporary heating/cooling during construction. Consult this LEED-CS v2.0 Reference Guide for more detailed information on how to ensure the well-being of construction workers and building occupants if permanently installed air handlers must be used during construction.

1 point

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Summary of Referenced Standards

IAQ Guidelines for Occupied Buildings Under Construction

Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

www.smacna.org

(703) 803-2980

This standard provides an overview of air pollutants associated with construction, control measures, construction process management, quality control, communications with occupants, and case studies. Consult the referenced standard for measures to protect the building HVAC system and maintain acceptable indoor air quality during construction and demolition activities.

ANSI/ASHRAE 52.2-1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org

(800) 527-4723

This standard presents methods for testing air cleaners for two performance characteristics: the ability of the device to remove particles from the air stream and the device's resistance to airflow. The minimum efficiency reporting value (MERV) is based on three composite average particle size removal efficiency (PSE) points. Consult the standard for a complete explanation of MERV value calculations.

Approach and Implementation

Strategies

This credit hinges on performance by the general contractor. The IAQ Manage-

ment Plan should be completed before construction begins and should include construction-related IAQ procedures in the pre-construction and construction progress meeting agendas. Education of subcontractors and all field personnel on the goals of the IAQ Management Plan and importance of following the plan's procedures ensures compliance and achievement. If warranted, select a member of the contractor's team to serve as the IAQ Manager who will have the responsibility to identify IAQ problems and their mitigation. The referenced SMACNA standard recommends control measures in five areas: HVAC protection, source control, pathway interruption, housekeeping and scheduling. For each project, review the applicability of each control measure and include those that apply in the final IAQ Management Plan. The control measures are as follows:

HVAC Protection

Ideally, permanently installed HVAC systems should not be used during the construction process as using this equipment can cause contamination of the HVAC system. In most cases, use of the HVAC system during construction activates the manufacturer's warranty, exposing the contractor to potential out-of-pocket costs if problems occur when the manufacturer's warranty has expired but the warranty for the building has not. Using temporary heaters is feasible, practical and generally not costly.

Protect all HVAC equipment from both dust and odors. Ideally, do not use the system during construction, particularly during demolition. Seal all duct and equipment openings with plastic. If the system must be operated to maintain service to other occupied portions of the building or to protect finished work be sure to protect the return/negative pressure side of the system. If the returns cannot be closed off, install and maintain temporary filters over grilles and openings. To

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comply with the credit requirements the filtration medium must have a rating of MERV 8 or better. If an unducted plenum over the construction zone must be used, isolate it by having all ceiling tiles in place. Leaks in the return ducts and air handlers should be checked. Make needed repairs promptly. Avoid using the mechanical rooms for construction storage.

Replace all filtration media immediately prior to occupancy, installing only a single set of final filtration media. Note that the requirement for MERV 13 rated filters has been moved to EQ Credit 5. This credit does not regulate the efficiency of the filters used for the long-term operation of the building.

Source Control

Specify finish materials such as paints, carpet, composite wood, adhesives, and sealants that have low toxicity levels, or none at all. The selection of low-emitting materials is covered under EQ Credit 4. The IAQ Management Plan should specify the control measures for materials containing VOCs. Recover, isolate and ventilate containers housing toxic materials. Also, avoid exhaust fumes from idling vehicles and gasoline fueled tools.

Pathway Interruption

During construction, isolate areas of work to prevent contamination of clean or occupied spaces. Depending on the weather conditions, ventilate using 100% outside air to exhaust contaminated air directly to the outside during installation of VOC-emitting materials. Depressurize the work area allowing the air pressure differential between construction and clean areas to contain dust and odors. Provide temporary barriers that contain the construction area.

Housekeeping

Institute cleaning activities designed to control contaminants in building spaces during construction and prior to occu-

pancy. Porous building materials should be protected from exposure to moisture and stored in a clean area prior to installation. Some other strategies are using vacuum cleaners with high efficiency particulate filters, increasing the cleaning frequency and utilizing wetting agents for dust.

Scheduling

Coordinate construction activities to minimize or eliminate disruption of operations in the occupied portions of the building. Construction activities over the duration of the project should be sequenced carefully to minimize the impact on the indoor air quality. It may be necessary to conduct activities with high pollution potential during off-hours, such as on the weekends or in the evenings to allow time for new materials to air out. Plan adequate time to complete work so flush-out and IAQ test procedures can be completed prior to occupancy. Upon completion of construction, replace all filtration media immediately prior to occupancy. This activity should be coordinated with the activities and requirements addressed in EQ Credit 3.2 and 5.

Utilizing temporary ventilation units is one strategy to meet the SMACNA control measure for HVAC protection, but does not on its own satisfy all of the requirements of this credit.

Core and Shell Considerations

For some core and shell building types, there is generally a period where ongoing core and shell construction is happening at the same time as tenant space build-out. This is generally at the point in the project when the building is completely enclosed and major building systems are in place. Core and shell projects should give careful consideration to coordination of the Construction IAQ Management Plan with tenant construction. Ideally, a tenant IAQ management plan would be developed in coordination with the core and shell construction team's IAQ Plan.

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While future tenant fit-outs are not addressed through LEED-CS, minimizing cross contamination of tenant spaces as future tenants build out their spaces should also be considered. A tenant pursuing a LEED-CI certification will need to consider this for the tenant space. SMACNA's IAQ Guidelines for Occupied Buildings Under Construction details many measures to help improve the IAQ of occupied buildings under construction. One of these measures is sealing off the return air system from the construction site. Another measure is providing local exhaust to the construction area to directly exhaust any contaminants from the construction. A comprehensive building Construction IAQ Management Plan can help reduce the complaints from existing tenants during construction of new tenant space.

Calculations

There are no calculations to support this credit.

Exemplary Performance

Core and shell projects that require and enforce a Construction IAQ Management Plan for 100% of the tenant spaces are eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Templates, which include the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide a copy of the project's Indoor Air Quality (IAQ) Management Plan.
- Confirm if the permanently installed air handling equipment was used during construction.
- Provide photos to highlight the implemented construction IAQ practices.
- List all filtration media (manufacturer, model #, MERV rating, location of installed filter) installed during construction and confirm that each was replaced prior to final occupancy.
- Provide an optional narrative describing any special circumstances or non-standard approaches taken by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Considerations

Building construction invariably introduces contaminants into the building. If unaddressed, the contamination can result in poor indoor air quality extending over the lifetime of the building. Fortunately there are IAQ management strategies, if instituted during construction and before occupancy, that will minimize potential problems.

Environmental Issues

Contaminant reduction is beneficial to building occupants, resulting in greater

comfort, lower absenteeism and greater productivity.

Economic Issues

Superior indoor air quality is likely to increase worker productivity translating to greater profitability for companies. Additional time and labor may be required during construction to protect and clean ventilation systems and building spaces. However, these actions can extend the lifetime of the ventilation system and improve ventilation system efficiency, resulting in reduced energy use. The sequencing of material installation may require additional time and could potentially delay the date of initial occupancy. Early coordination between the contractor and subcontractors can minimize or eliminate scheduling delays.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Controlling Pollutants and Sources

U.S. Environmental Protection Agency

www.epa.gov/iaq/schooldesign/controlling.html

Detailed information on exhaust or spot ventilation practices during construction activity can be found toward the end of the webpage at the abovementioned URL address.

The State of Washington (SOW) Program and IAQ Standards

<http://www.aerias.org/DesktopModules/ArticleDetail.aspx?articleId=85>

This IAQ standard for the state of Washington was the first state-initiated program to ensure the design of buildings with acceptable indoor air quality.

Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA)

www.smacna.org

(703) 803-2980

SMACNA is a professional trade association that publishes the referenced standard as well as *Indoor Air Quality: A Systems Approach*, a comprehensive discussion of the sources of pollutants, measurement, methods of control, and management techniques.

Print Media

Indoor Air Quality, Construction Technology Centre Atlantic. Written as a comprehensive review of indoor air quality issues and solutions, the report is available for purchase from http://ctca.unb.ca/CTCA/communication/IAQ/Order_IAQ.htm or by calling (506) 453-5000.

Definitions

A Construction IAQ Management Plan

is a document specific to a building project that outlines measures to minimize contamination in the building during construction and to flush the building of contaminants prior to occupancy.

HVAC Systems include heating, ventilating, and air-conditioning systems used to provide thermal comfort and ventilation for building interiors.

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Low-Emitting Materials

Adhesives & Sealants

Intent

Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Requirements

All adhesives and sealants used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the requirements of the following reference standards:

- Adhesives, Sealants and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168. VOC limits are listed in the table below and correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.

Table 1: SCAQMD VOC Limits

Architectural Applications	VOC Limit [g/L less water]	Specialty Applications	VOC Limit [g/L less water]
Indoor Carpet Adhesives	50	PVC Welding	510
Carpet Pad Adhesives	50	CPVC Welding	490
Wood Flooring Adhesives	100	ABS Welding	325
Rubber Floor Adhesives	60	Plastic Cement Welding	250
Subfloor Adhesives	50	Adhesive Primer for Plastic	550
Ceramic Tile Adhesives	65	Contact Adhesive	80
VCT & Asphalt Adhesives	50	Special Purpose Contact Adhesive	250
Drywall & Panel Adhesives	50	Structural Wood Member Adhesive	140
Cove Base Adhesives	50	Sheet Applied Rubber Lining Operations	850
Multipurpose Construction Adhesives	70	Top & Trim Adhesive	250
Structural Glazing Adhesives	100		
Substrate Specific Applications	VOC Limit [g/L less water]	Sealants	VOC Limit [g/L less water]
Metal to Metal	30	Architectural	250
Plastic Foams	50	Nonmembrane Roof	300
Porous Material (except wood)	50	Roadway	250
Wood	30	Single-Ply Roof Membrane	450
Fiberglass	80	Other	420
Sealant Primers	VOC Limit [g/L less water]		
Architectural Non Porous	250		
Architectural Porous	775		
Other	750		

1 Point
for Achievement
of 2 Requirements
(4.1, 4.2, 4.3 or 4.4)

2 Points
for Achievement
of 3 Requirements
(4.1, 4.2, 4.3 or 4.4)

3 Points
for Achievement
of 4 Requirements
(4.1, 4.2, 4.3 or 4.4)

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Table 2: Greenseal VOC Limits

Aerosol Adhesives	VOC Weight [g/L minus water]
General purpose mist spray	65% VOCs by weight
General purpose web spray	55% VOCs by weight
Special purpose aerosol adhesives (all types)	70% VOCs by weight

Potential Technologies & Strategies

Specify low-VOC materials in construction documents. Ensure that VOC limits are clearly stated in each section of the specifications where adhesives and sealants are addressed. Common products to evaluate include general construction adhesives, flooring adhesives, fire-stopping sealants, caulking, duct sealants, plumbing adhesives, and cove base adhesives.

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Credit 4.1					

Summary of Referenced Standards

South Coast Rule #1168 October 3, 2003 Amendment by the South Coast Air Quality Management District

South Coast Air Quality Management District

www.aqmd.gov/rules/reg/reg11/r1168.pdf

(909) 396-2000

The South Coast Air Quality Management District is a governmental organization in Southern California with the mission to maintain healthful air quality for its residents. The organization established source specific standards to reduce air quality impacts. The South Coast Rule #1168 VOC limits for adhesives are summarized in Table 1.

Green Seal Standard 36 (GS-36), Effective October 19, 2000

www.greenseal.org/standards/commercialadhesives.htm

Green Seal is an independent nonprofit organization that promotes the manufacture and sale of environmentally responsible consumer products. GS-36 is a standard that sets VOC limits for commercial adhesives.

Approach and Implementation

See the Supplemental Section at the end of this credit for all EQ Credit 4 instructions.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

Core and shell projects that require and enforce compliance with the suite of EAc 4 credits for 100% of the tenant

spaces are eligible for one exemplary performance point under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide a listing of each indoor adhesive, sealant and sealant primer product used on the project. Include the manufacturer's name, product name, specific VOC data (in g/L, less water) for each product, and the corresponding allowable VOC from the referenced standard.
- Provide a listing of each indoor aerosol adhesive product used on the project. Include the manufacturer's name, product name, specific VOC data (in g/L, less water) for each product, and the corresponding allowable VOC from the referenced standard.
- Provide a narrative to describe any special circumstances or non-stan-

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Credit 4.1					

standard compliance paths taken by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

South Coast Rule #1168 by the South Coast Air Quality Management District South Coast Air Quality Management District

www.aqmd.gov/rules/reg/reg11/r1168.pdf
(909) 396-2000

The South Coast Air Quality Management District is a governmental organization in Southern California with the mission to maintain healthful air quality for its residents. The organization established source specific standards to reduce air quality impacts. The South Coast Rule #1168 VOC limits for adhesives are summarized in Table 1.

Green Seal Standard 36 (GS-36)

www.greenseal.org/standards/commercialadhesives.htm

Green Seal is an independent nonprofit organization that promotes the manufacture and sale of environmentally responsible consumer products. GS-36 is a standard that sets VOC limits for commercial adhesives.

Definitions

Adhesive is any substance that is used to bond one surface to another surface by attachment. Adhesives include adhesive bonding primers, adhesive primers,

adhesive primers for plastics, and any other primer.

Aerosol Adhesive is an adhesive packaged as an aerosol product in which the spray mechanism is permanently housed in a non-refillable can designed for hand-held application without the need for ancillary hoses or spray equipment. Aerosol adhesives include special purpose spray adhesives, mist spray adhesives and web spray adhesives.

Indoor Adhesive, Sealant and/or Sealant Primer product is defined as an adhesive or sealant product applied on-site, inside of the building's weatherproofing system.

Porous Sealant is a substance used as a sealant on porous materials. Porous materials have tiny openings, often microscopic, in which fluids may be absorbed or discharged. Such materials include, but are not limited to, wood, fabric, paper, corrugated paperboard and plastic foam.

Primer is a material applied to a substrate to improve adhesion of subsequently applied adhesive.

Non-porous Sealant is a substance used as a sealant on non-porous materials. Non-porous materials do not have openings in which fluids may be absorbed or discharged. Such materials include, but are not limited to, plastic and metal.

A **Sealant** is any material with adhesive properties that is formulated primarily to fill, seal, or waterproof gaps or joints between two surfaces. Sealants include sealant primers and caulks.

VOC (Volatile Organic Compounds) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize (become a gas) at normal room temperatures.

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Credit 4.2					

Low-Emitting Materials

Paints & Coatings

Intent

Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Requirements

Paints and coatings used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the following criteria:

- Architectural paints, coatings and primers applied to interior walls and ceilings: Do not exceed the VOC content limits established in Green Seal Standard GS-11, Paints, First Edition, May 20, 1993.
 - Flats: 50 g/L
 - Non-Flats: 150 g/L
- Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates: Do not exceed the VOC content limit of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997.
- Clear wood finishes, floor coatings, stains, and shellacs applied to interior elements: Do not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004.
 - Clear wood finishes: varnish 350 g/L; lacquer 550 g/L
 - Floor coatings: 100 g/L
 - Shellacs: clear 730 g/L; pigmented 550 g/L
 - Sealers: waterproofing sealers 250g/L; sanding sealers 275 g/L; all other sealers 200 g/L
 - Stains: 250 g/L

Potential Technologies & Strategies

Specify low-VOC paints and coatings in construction documents. Ensure that VOC limits are clearly stated in each section of the specifications where paints and coatings are addressed. Track the VOC content of all interior paints and coatings during construction.

1 Point
for Achievement
of 2 Requirements
(4.1, 4.2, 4.3 or 4.4)

2 Points
for Achievement
of 3 Requirements
(4.1, 4.2, 4.3 or 4.4)

3 Points
for Achievement
of 4 Requirements
(4.1, 4.2, 4.3 or 4.4)

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Credit 4.2					

Summary of Referenced Standards

Green Seal Standard GS-11

www.greenseal.org/standards/paints.htm

(202) 872-6400

Green Seal is an independent nonprofit organization that promotes the manufacture and sale of environmentally responsible consumer products. GS-11 is a standard that sets VOC limits for commercial flat and non-flat paints.

Green Seal Standard GS-03

www.greenseal.org/standards/anti-corrosivepaints.htm

(202) 872-6400

GS-03 is a Green Seal standard that sets VOC limits for anti-corrosive and anti-rust paints.

South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings

www.aqmd.gov/rules/reg/reg11/r1113.pdf

The South Coast Air Quality Management District is a governmental organization in Southern California with the mission to maintain healthful air quality for its residents. The organization established source specific standards to reduce air quality impacts.

Approach and Implementation

See the Supplemental Section at the end of this credit for all EQ Credit 4 instructions.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

Core and shell projects that require and enforce compliance with the suite of EAc 4 credits for 100% of the tenant spaces are eligible for one exemplary performance point under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide a listing of each indoor paint and coating used on the project. Include the manufacturer's name, product name, specific VOC data (in g/L) for each product, and the corresponding allowable VOC from the referenced standard.
- Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Green Seal

www.greenseal.org

South Coast Air Quality Management District

www.aqmd.gov

Definitions

Anti-corrosive Paints are coatings formulated and recommended for use in preventing the corrosion of ferrous metal substrates.

Paint is a liquid, liquefiable or mastic composition that is converted to a solid protective, decorative, or functional adherent film after application as a thin layer. These coatings are intended for on-site application to interior or exterior surfaces of residential, commercial, institutional or industrial buildings.

Indoor Paint or Coating Product is defined as a paint or coating product applied on-site inside of the building's weatherproofing system.

Flat Coatings are coatings that register a gloss of less than 15 on an 85-degree meter or less than 5 on a 60-degree meter.

Non-flat Coatings are coatings that register a gloss of 5 or greater on a 60-degree meter and a gloss of 15 or greater on an 85-degree meter.

Primer is a material applied to a substrate to improve adhesion of subsequently applied adhesive.

VOCs (Volatile Organic Compounds) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize (become a gas) at normal room temperatures.

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SS	WE	EA	MR	EQ	ID
Credit 4.2					

Low-Emitting Materials

Carpet Systems

Intent

Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Requirements

All carpet installed in the building interior shall meet the testing and product requirements of the Carpet and Rug Institute's Green Label Plus™ program.

All carpet cushion installed in the building interior shall meet the requirements of the Carpet and Rug Institute Green Label program.

All carpet adhesive shall meet the requirements of EQ Credit 4.1: VOC limit of 50 g/L.

Potential Technologies & Strategies

Clearly specify requirements for product testing and/or certification in the construction documents. Select products that are either certified under the Green Label Plus program or for which testing has been done by qualified independent laboratories in accordance with the appropriate requirements.

The Green Label Plus program for carpets and its associated VOC emission criteria in micrograms per square meter per hour, along with information on testing method and sample collection developed by the Carpet & Rug Institute (CRI) in coordination with California's Sustainable Building Task Force and the California Department of Health Services (DHS), are described in Section 9, Acceptable Emissions Testing for Carpet, DHS Standard Practice CA/DHS/EHLB/R-174, dated 07/15/04. This document is available at: www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/Section01350_7_15_2004_FINAL_PLUS_ADDENDUM-2004-01.pdf. (also published as Section 01350 Section 9 [dated 2004] by the Collaborative for High Performance Schools [www.chps.net]).

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Credit 4.3					

1 Point
for Achievement
of 2 Requirements
(4.1, 4.2, 4.3 or 4.4)

2 Points
for Achievement
of 3 Requirements
(4.1, 4.2, 4.3 or 4.4)

3 Points
for Achievement
of 4 Requirements
(4.1, 4.2, 4.3 or 4.4)

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Credit 4.3					

Summary of Referenced Standard

Carpet and Rug Institute Green Label Plus Testing Program

Carpet and Rug Institute

www.carpet-rug.com

(800) 882-8846

The Carpet and Rug Institute is a trade organization representing the carpet and rug industry. Green Label Plus is an independent testing program that identifies carpets with very low emissions of volatile organic compounds (VOCs). The “Green Label Plus” program for carpets and its associated VOC emission criteria in micrograms per square meter per hour developed by the Carpet & Rug Institute (CRI) in coordination with California’s Sustainable Building Task Force and the California Department of Health Services (DHS) are described on the CRI website. In the CRI Green Label Plus Program, emission rates must be verified by conducting annual testing. Valid/approved certification numbers can be reviewed on the CRI website under Indoor Air Quality/Green Label Plus/Approved companies. Approved products are listed under the company heading.

Testing Criteria

Carpet must not exceed the maximum target emission factors used in the CRI Green Label program and comply with the test protocol used by Green Label Plus. Test results submitted must be no more than 2 years old at the time of submission. Standard Practice for the Testing of Volatile Organic Emissions from Various Sources using Small-Scale Environmental Chambers (State of California Standard 1350), Section 9

www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/Section01350_7_15_2004_FINAL_PLUS_ADDENDUM-2004-01.pdf

This standard practice document specifies testing criteria for carpet emissions that will satisfy the credit requirements.

Approach and Implementation

See the Supplemental Section at the end of this credit for all EQ Credit 4 instructions.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

Core and shell projects that require and enforce compliance with the suite of EA4 credits for 100% of the tenant spaces are eligible for one exemplary performance point under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide a listing of each carpet product installed in the building interior. Confirm that the product complies with the CRI Green Label Plus testing program.
- Provide a listing of each carpet cushion product installed in the building interior. Confirm that the product complies with the CRI Green Label testing program.
- Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Carpet and Rug Institute

www.carpet-rug.org

Definitions

Indoor carpet systems are defined as carpet, carpet adhesive, or carpet cushion product installed on-site inside of the building's weatherproofing system.

VOCs (Volatile Organic Compounds) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon di-

oxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize (become a gas) at normal room temperatures.

SS	WE	EA	MR	EQ	ID
Credit 4.3					

SS	WE	EA	MR	EQ	ID
Credit 4.3					

Low-Emitting Materials

Composite Wood & Agrifiber Products

Intent

Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Requirements

Composite wood and agrifiber products used on the interior of the building (defined as inside of the weatherproofing system) shall contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies shall contain no added urea-formaldehyde resins.

Composite wood and agrifiber products are defined as: particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. Furniture and fixtures are not considered base building elements and are not included.

Potential Technologies & Strategies

Specify wood and agrifiber products that contain no added urea-formaldehyde resins. Specify laminating adhesives for field and shop applied assemblies that contain no added urea-formaldehyde resins.

SS	WE	EA	MR	EQ	ID
Credit 4.4					

1 Point
for Achievement
of 2 Requirements
(4.1, 4.2, 4.3 or 4.4)

2 Points
for Achievement
of 3 Requirements
(4.1, 4.2, 4.3 or 4.4)

3 Points
for Achievement
of 4 Requirements
(4.1, 4.2, 4.3 or 4.4)

SS	WE	EA	MR	EQ	ID
Credit 4.4					

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

See the Supplemental Section at the end of this credit for all EQ Credit 4 instructions.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

Core and shell projects that require and enforce compliance with the suite of EAc 4 credits for 100% of the tenant spaces are eligible for one exemplary performance point under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide a listing of each composite wood and agrifiber product installed in the building interior. Confirm that each product does not contain any added urea-formaldehyde.
- Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

An Update on Formaldehyde

Consumer Product Safety Commission
www.cpsc.gov/CPSCPUB/PUBS/725.html

An informational document from the Consumer Product Safety Commission.

Definitions

Agrifiber Board is a composite panel product derived from recovered agricultural waste fiber from sources including, but not limited to, cereal straw, sugarcane bagasse, sunflower husk, walnut shells, coconut husks, and agricultural prunings. The raw fibers are processed and mixed with resins to produce panel products with characteristics similar to those de-

rived from wood fiber. The following conditions describe which products must comply with the requirements:

1. The product is inside of the building's waterproofing system.
2. Composite components used in assemblies are to be included (e.g., door cores, panel substrates, etc.)
3. The product is part of the base building systems.

Composite Wood is a product consisting of wood or plant particles or fibers bonded together by a synthetic resin or binder. Examples: plywood, particle-board, OSB, MDF, composite door cores. For the purposes of this credit, the following conditions describe which products must comply with the requirements:

1. The product is inside of the building's waterproofing system.
2. Composite wood components used in assemblies are included (e.g., door cores, panel substrates, plywood sections of I-beams).
3. The product is part of the base building systems.

Formaldehyde is a naturally occurring VOC found in small amounts in animals and plants, but is carcinogenic and an irritant to most people when present in high concentrations—causing headaches, dizziness, mental impairment, and other symptoms. When present in the air at levels above 0.1 ppm parts of air, it can cause watery eyes, burning sensations in the eyes, nose and throat; nausea; coughing; chest tightness; wheezing; skin rashes; and asthmatic and allergic reactions.

Indoor Composite Wood or Agrifiber product is defined as a composite wood or agrifiber product installed on-site, inside of the building's weatherproofing system.

Laminate Adhesive is an adhesive used in wood/agrifiber products (veneered panels, composite wood products contained in engineered lumber, door assemblies, etc.).

Urea Formaldehyde is a combination of urea and formaldehyde that is used in some glues and may emit formaldehyde at room temperature.

Phenol Formaldehyde, which off-gasses only at high temperature, is used for exterior products, although many of those products are suitable for interior applications.

SS	WE	EA	MR	EQ	ID
Credit 4.4					

SS	WE	EA	MR	EQ	ID
Credit 4.4					

SS	WE	EA	MR	EQ	ID
Credit 4					

Supplemental Information

Approach and Implementation

The four parts of LEED-CS EQ Credit 4 apply to products and installation processes that have the potential to adversely affect the indoor air quality (IAQ) of a project space and, in turn, those exposed to the contaminants these materials may off-gas.

Because core and shell buildings do not have direct control over the tenant spaces, the owner/developer's ability to affect the building's overall indoor air quality through the selection of Low VOC materials and products is diminished. Core and shell buildings are encouraged to communicate the benefits of low VOC materials to their tenants through Tenant Design and Construction Guidelines. Projects may want to consider going beyond this and mandate specific materials with proven VOC off-gassing performance as requirements for the build-out of all tenant spaces.

Strategies

The requirements for products and activities covered in EQ Credit 4 should be noted in the project specifications and, ideally, within the specific section of the document applicable to a particular trade or supplier.

Design Phase

In order to achieve this goal, credit requirements should be clearly stated in project specifications. Reference the credit requirements in both Division 1 and in the technical divisions. Indicate what must be provided in the way of cut sheets, material safety data sheets (MSD sheets), certificates and test reports. Consider making submittal of this compliance documentation a condition of product approval.

Construction Phase

Meeting the requirements set forth in EQ Credit 4 may not be common practice for all construction teams and suppliers. Consider asking the project owner to stress the importance of meeting the LEED requirements during pre-bid meetings and again at the time of contract award. During these sessions, have LEED Accredited Professionals available and solicit questions from bidding contractors. Include requirements in subcontract and purchase order language.

Composition Limits

All materials that emit contaminants that have the potential to enter the indoor air will be considered as indoor sources of contaminants. Materials which have the potential to communicate their emissions to the indoor air include all indoor surfaces in contact with the indoor air including flooring; walls; ceilings; interior furnishings; suspended ceiling systems and the materials above those suspended ceilings; all ventilation system components in communication with the ventilation supply or return air; and all materials inside of wall cavities, ceiling cavities, floor cavities, or horizontal or vertical chases. These materials include the caulking materials for windows and insulation in ceilings or walls. An example of a material that has little or no potential for communicating with the indoor air is siding that is on the exterior side of the waterproofing membrane. In this approach the formulation of a product is controlled. Limits are set

SS	WE	EA	MR	EQ	ID
Credit 4					

on the amount of volatile organic compounds (VOCs) permitted in a given volume of the product. The threshold limits and the content within a particular product are generally expressed in grams per liter (g/L). EQ Credits 4.1 and 4.2 use this approach for adhesives, sealants, paints and coatings. EQ Credit 4.4 also controls formulation by setting a limit of zero added urea-formaldehyde resins.

Emission Factors

This standard sets a limit on the rate that off-gassing may occur. The rate is stated as the mass of contaminant that may be off-gassed by a given unit quantity of the product in a set period of time. This approach is used in EQ Credit 4.3 for carpet where the rate is expressed as micrograms of contaminant per square meter of carpet per hour. These tests, which are now being done on an array of product types, place samples of precise size in test chambers.

Air samples are drawn off at set times, generally over several days, and analyzed. There are extensive protocols established to make the testing representative of actual conditions on a project site and consistent between similar products from multiple manufactures. The Carpet and Rug Institute (CRI) Green Label Plus program uses emission factor test results for its certifications.

VOC Budgets

This alternative compliance path allows for specialty applications for which there is no low-VOC product option. It may be used with adhesives and sealants covered in EQ Credit 4.1 and with paints and coatings covered in EQ Credit 4.2. The documentation must demonstrate that the overall low-VOC performance has been attained for paints and adhesives separately, not in combination. The calculation is a comparison between a baseline case and the design case. When the design (or actual) is less than the baseline, the credit requirement is satisfied. The values used in the comparison are the total VOCs contained in the products (i.e., paint) used on the project. The total VOCs is determined by multiplying the volume of the product used by the threshold VOC level for the baseline case and actual product VOC level for the design case. The baseline application rate should not be greater than that used in the design case. When submitting a VOC budget calculation, also provide the supporting documentation concerning the product—the name, application rate, class or use to confirm that the correct threshold VOC level has been used in determining the baseline case, and finally the actual VOC level of the product. As the term “budget” implies, this compliance path should be a decision planned in advance. Occasionally, honest mistakes occur—even on LEED projects. If realized in time, this approach may be used to determine if credit compliance can be attained. A narrative explaining the situation should accompany the project submittal, but project teams should never “paint” their way out of a mistake. Additional coats, even with products below the threshold limits, add to the overall level of off-gassed VOCs. It is not enough to meet the requirements; the intent also has to be met to earn the credit.

Considerations

A large number of building products contain compounds that have a negative impact on indoor air quality and the Earth’s atmosphere. The most prominent of these compounds, volatile organic compounds (VOCs), contribute to smog generation and air pollution outdoors while having an adverse effect on the well-being of building

SS	WE	EA	MR	EQ	ID
Credit 4					

occupants indoors. By selecting low-emitting materials, both outdoor and indoor air quality impacts can be reduced.

Environmental Issues

VOCs react with sunlight and nitrogen oxides in the atmosphere to form ground-level ozone, a chemical that has a detrimental effect on human health, agricultural crops, forests and ecosystems. Ozone damages lung tissue, reduces lung function, and sensitizes the lungs to other irritants. Ozone is also a major component of smog, which affects agricultural crops and forestland.

Economic Issues

Healthy occupants are more productive and have less illness-related absenteeism. Use of high-VOC content materials can cause illness and may decrease occupant productivity. These problems result in increased expenses and liability for building owners, operators and insurance companies. As a result, the construction market is driving product manufacturers to offer low-VOC alternatives to conventional building products. Costs for these low-VOC products are generally competitive with conventional materials. However, some low-VOC materials are more expensive than conventional materials, particularly when the products are first introduced to the marketplace. Low-VOC products may also be difficult to obtain for some product types. However, these problems will recede as application of low-VOC products become more commonplace.

Synergies and Trade-Offs

Selecting materials that are low in VOCs helps reduce sources of pollutants during the construction process and in the finished building. There are typically multiple products available that meet these criteria for a wide variety of applications. However, these criteria must be balanced against other green building considerations, such as location of manufacture, durability and performance.

Case Study

171 17th Street Atlanta, Georgia

171 17th Street, the first commercial high-rise in the Atlantic Station® development, achieved a LEED-CS Pilot Silver Certification. The structure is a 21-story, 500,000-sq.ft. commercial office tower on a 138-acre mixed-use urban redevelopment of the former Atlantic Steel Mill. The office tower incorporates several sustainable elements, such as materials with recycled contents, carbon dioxide sensors and low VOC paints, sealants and adhesives. These features, along with Atlantic Station's central location, thoughtful site design and incorporation of alternative transportation, combine to create a higher quality indoor and outdoor environment for 171 17th Street occupants.



Photo courtesy of: The Epsten Group

SS	WE	EA	MR	EQ	ID
Credit 4					

SS	WE	EA	MR	EQ	ID
Credit 5					

Indoor Chemical & Pollutant Source Control

Intent

Minimize exposure of building occupants to potentially hazardous particulates and chemical pollutants.

1 point

Requirements

Design to minimize and control pollutant entry into buildings and later cross-contamination of regularly occupied areas:

- Employ permanent entryway systems at least six feet long in the primary direction of travel to capture dirt and particulates from entering the building at all entryways that are directly connected to the outdoors. Acceptable entryway systems include permanently installed grates, grilles, or slotted systems that allow for cleaning underneath. Roll-out mats are only acceptable when maintained on a weekly basis by a contracted service organization. Qualifying entryways are those that serve as regular entry points for building users.
- Where hazardous gases or chemicals may be present or used (including garages, housekeeping/laundry areas and copying/printing rooms), exhaust each space sufficiently to create negative pressure with respect to adjacent spaces with the doors to the room closed. For each of these spaces, provide self-closing doors and deck to deck partitions or a hard lid ceiling. The exhaust rate shall be at least 0.50 cfm/sq.ft., with no air re-circulation. The pressure differential with the surrounding spaces shall be at least 5 Pa (0.02 inches of water gauge) on average and 1 Pa (0.004 inches of water) at a minimum when the doors to the rooms are closed.
- In mechanically ventilated buildings, provide regularly occupied areas of the building with air filtration media prior to occupancy that provides a Minimum Efficiency Reporting Value (MERV) of 13 or better. Filtration should be applied to process both return and outside air that is to be delivered as supply air.

Potential Technologies & Strategies

Design facility cleaning and maintenance areas with isolated exhaust systems for contaminants. Maintain physical isolation from the rest of the regularly occupied areas of the building. Install permanent architectural entryway systems such as grilles or grates to prevent occupant-borne contaminants from entering the building. Install high-level filtration systems in air handling units processing both return air and outside supply air. Ensure that air handling units can accommodate required filter sizes and pressure drops.

SS	WE	EA	MR	EQ	ID
Credit 5					

Summary of Referenced Standard

ANSI/ASHRAE 52.2-1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org

(800) 527-4723

This standard presents methods for testing air cleaners for two performance characteristics: the ability of the device to remove particles from the air stream and the device's resistance to airflow. The minimum efficiency reporting value (MERV) is based on three composite average particle size removal efficiency (PSE) points. Consult the standard for a complete explanation of MERV value calculations. **Table 1** summarizes the requirements for a MERV value of 13.

Approach and Implementation

The indoor air quality of buildings is adversely affected by seemingly benign activities of daily occupancy and operations. Occupants and building visitors contribute to IAQ issues within buildings by tracking in contaminants on their shoes and clothing. Daily copier, fax and printer operations add contaminants to the building's interior environment. Additionally, the storage, mixing and disposal of housekeeping liquids may adversely affect the health and productivity of building occupants. This credit strives to improve indoor environmental conditions by mitigating the amount of

particulate, chemical and biological contaminants that occupants are exposed to inside buildings.

Incorporate permanent entryway systems, which remove debris from shoes, at all high-traffic exterior access points to reduce the amount of contaminants tracked into the occupied space by people. The entryway systems should be designed to capture and remove particles from shoes without allowing build-up of contaminants. Open grates/grilles or other entryway systems that have a recessed collection area are generally thought to be most effective. (Carpeted systems are not regarded as providing the same effectiveness in particulate removal as open grid type systems and require continuous cleaning/maintenance to avoid build-up of dirt and debris.)

High traffic exterior access points will always include the main building entry, but may not be limited to this. Buildings that have entries from structured parking will have a high volume of use in these locations. In some instances these entry points are inside of a garage structure. While a covered garage does provide protection from the elements, as a source of possible contaminants, it functions as a direct connection to the outdoors. Likewise, buildings that may have distinct employee and visitor entry points should include permanent entryway systems in these locations as well. Projects should evaluate all building entry points to determine whether permanent entryway systems should be incorporated.

Retail or mixed-use core and shell buildings with tenant retail spaces that have access from the exterior should also provide a permanent entryway system or properly maintained walk-off mats in these loca-

Table 1: Requirements for a MERV Value 13

Composite Average Particle Size Efficiency [%]			Minimum Final Resistance	
0.30 – 1.0 µm	1.0 – 3.0 µm	3.0 – 10.0 µm	[Pa]	[in. of water]
< 75%	≥90%	≥90%	350	1.4

SS	WE	EA	MR	EQ	ID
Credit 5					

tions. This should be provided in all areas that the core and shell owner/developer is able to control. In some instances the tenant, not the developer, will determine the location of the exterior entries. In such cases, properly maintained interior walk-off mats are a viable solution.

Locate high-volume copy, print and fax equipment away from occupant work spaces in enclosed rooms with self-closing doors. In order to effectively remove airborne contaminants generated by this type of equipment, the rooms must be physically separated from adjacent spaces. This may be accomplished through installation of deck to deck partitions or sealed gypsum board enclosures. Rooms with large openings but no doors will not be able to meet the credit requirement. To remove airborne contaminants, and prevent cross-contamination into occupied spaces, copy, print and/or fax rooms must be equipped with a dedicated exhaust system (no return air) that creates a negative pressure within the room meeting the requirements of this credit. Convenience (small) copier and printer use should be minimized where possible. Although encouraged, designing exhaust systems that account for convenience copier and printer use is not required for this credit.

Chemical storage and mixing areas, such as janitor's closets and photo labs should also be located away from occupant work areas. Additionally, these rooms must be physically separated from adjacent spaces via installation of deck-to-deck partitions or sealed gypsum board enclosures. Rooms must be equipped with a dedicated exhaust system (no return air) that creates the required negative pressurization to ensure that cross contamination into adjacent occupied spaces will not occur.

All building HVAC systems must be designed to accommodate filtration systems with a minimum MERV 13 rating.

Additional ventilation systems to mitigate contaminating space activities may affect building energy performance and require commissioning and Measurement & Verification attention. Ventilation system design will also be affected to ensure that installed systems are capable of accommodating filtration media required for credit compliance. This may be difficult to achieve for spaces with low capacity, packaged air handling systems, due to the size of these filters and their associated pressure drop. The selected space layout may prohibit deck-to-deck separation and separate ventilation systems for chemical use areas. Storage areas for recyclable materials may also be considered to be contaminant sources, depending on the items recycled. Janitorial supplies may impact indoor air quality if not wisely chosen.

Core and Shell Considerations

Many core and shell buildings include structured parking as an integrated part of the project. Projects that include parking levels or attached structured parking should consider these entry points as directly connected to the outdoors.

Another aspect of speculative core and shell buildings is the level of control the building owner/developer has over the different spaces in a multiple use building. For example, a commercial office building may have a retail component at the ground level. The final location of each of these tenant entries will be determined based on the needs and demands of the tenant, outside of the direct control of the core and shell owner. Entry points such as these are encouraged to install permanent entryway systems or properly maintained walk-off mats but, because the owner/developer does not directly control them, are not required to comply with this credit's requirements for a LEED-CS submission.

As is the case in all core and shell credits, the requirements of the credit exclude the

SS	WE	EA	MR	EQ	ID
Credit 5					

fit out of the tenant spaces. Tenant space activities such as copier, fax and printer use are not considered for the LEED-CS submission. Including this information in the Tenant Design and Construction Guidelines should be considered. Because the decisions of one tenant can impact the indoor environmental quality of the other tenants, LEED-CS projects should consider making these requirements of the tenants lease.

Calculations

There are no specific calculations associated with this credit.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the Owner/Developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document

credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide confirmation that required entryway systems have been installed.
- Provide a listing of each entryway product installed in the building. For roll-up or carpeted systems, confirm that the required contracted maintenance will take place.
- Provide copies of the project's construction drawings to highlight the location of the installed entryway systems.
- Confirm that chemical use areas have been designed as separate rooms with dedicated exhaust systems and appropriate negative pressurization.
- Provide copies of the project's mechanical drawings to highlight the location of chemical usage areas, room separations, and the associated exhaust systems.
- If mechanically ventilated, confirm that the installed filters have a MERV rating of 13 or better.
- Provide a listing of the installed filters and their associated MERV ratings.
- Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is available to core and shell projects that incorporate into tenant sales or lease agreements language that requires compliance with this credit as part of the tenant scope of work. Provide the LEED letter template for the credit pursued indicating the following:

- 100% of leased square footage is required to comply with credit requirements. Lease or sales agreements may be requested.

SS	WE	EA	MR	EQ	ID
Credit 5					

- ❑ 100% of the unleased square footage shall comply with the credit requirements when leased. A statement signed by the owner/developer that all leases and/or sales agreements will comply may be requested.
- ❑ Provide confirmation that entryway systems are required, including a description of the entryway system specified. For roll-up or carpeted systems, confirm that the required contracted maintenance will take place.
- ❑ Provide a drawing indicating the locations where the entryway systems will be installed.
- ❑ Provide confirmation that chemical use areas are required to be designed as separate rooms with dedicated exhaust systems and appropriate negative pressurization. Indicate the expected tenant spaces where this will be a requirement.
- ❑ Confirm that the required filters have a MERV rating of 13 or better.
- ❑ Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Cost Issues

Additional sinks, drains, room separations, and separate exhausts for copying and housekeeping areas can increase the project's overall initial cost. Also, dedicated ventilation and exhaust systems may require additional ductwork and associated installation costs. However, effective cleaning spaces and systems coupled with good human health initiatives should prove economically sound over the lifetime of the building. Clean air can help support worker productivity, and this translates into increased profitability for the company. Reducing the potential for spills can avoid costly environmental cleanups.

Community Issues

Good housekeeping benefits the community by reducing the potential for chemical spills that can impact neighboring properties. An environmentally sound building also supports the well-being of occupants, which may contribute to lowering health insurance rates and healthcare costs.

Regional Issues

Local weather conditions should be factored into determining the location and type of entryway systems. For example, in areas that are prone to large amounts of rain or snow, it may be prudent to locate entryway systems in an enclosed vestibule or inside the building. A floor drain beneath the grille may also be necessary to remove collected moisture.

Environmental Issues

Additional materials and energy may be required to provide entryway systems and isolated chemical use areas. This can increase natural resource consumption as well as air and water pollution. However, through proper management of hazardous chemicals used for building operations and maintenance, chemical spills and accidents can be avoided that would otherwise harm wildlife and ecosystems.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Green Seal

www.greenseal.org/recommendations.htm

(202) 872-6400

Green Seal is an independent nonprofit organization that promotes the manufacture and sale of environmentally respon-

SS	WE	EA	MR	EQ	ID
Credit 5					

sible consumer products. This website contains product recommendations for general purpose cleaning solutions.

Janitorial Products Pollution Prevention Project

www.westp2net.org/janitorial/jp4.htm

A governmental and nonprofit project that researches issues and provides fact sheets, tools and links.

EPA Environmentally Preferable Product Information

www.epa.gov/opptintr/epp/

This website includes links to cleaning product information and a database of environmental information on over 600 products, including janitorial and pest control products.

Print Media

Clean and Green: The Complete Guide to Non-Toxic and Environmentally Safe Housekeeping by Annie Berthold-Bond, Ceres Press, 1994.

Controllability of Systems

Thermal Comfort

Intent

Provide a high level of thermal comfort system control by individual occupants or by specific groups in multi-occupant spaces (i.e., classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

Requirements

Provide individual comfort controls for 50% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences. Operable windows can be used in lieu of comfort controls for occupants of areas that are 20 feet inside of and 10 feet to either side of the operable part of the window. The areas of operable window must meet the requirements of ASHRAE 62.1-2004, paragraph 5.1, Natural Ventilation.

AND

Provide comfort system controls for all shared multi-occupant spaces to enable adjustments to suit group needs and preferences.

Conditions for thermal comfort are described in ASHRAE Standard 55-2004 to include the primary factors of air temperature, radiant temperature, air speed and humidity. Comfort system control, for the purposes of this credit, is defined as the provision of control over at least one of these primary factors in the occupant's local environment.

Core and shell buildings that do not purchase and/or install the mechanical system or operable windows (or a combination of both) have not met the intent of this credit.

See Appendix 1 – Default Occupancy Counts for occupancy count requirements and guidance.

Potential Technologies & Strategies

Design the building and systems with comfort controls to allow adjustments to suit individual needs or those of groups in shared spaces. ASHRAE Standard 55-2004 identifies the factors of thermal comfort and a process for developing comfort criteria for building spaces that suit the needs of the occupants involved in their daily activities. Control strategies can be developed to expand on the comfort criteria to allow adjustments to suit individual needs and preferences. These may involve system designs incorporating operable windows, hybrid systems integrating operable windows and mechanical systems, or mechanical systems alone. Individual adjustments may involve individual thermostat controls, local diffusers at floor, desk or overhead levels, or control of individual radiant panels, or other means integrated into the overall building, thermal comfort systems, and energy systems design. In addition, designers should evaluate the closely tied interactions between thermal comfort (as required by ASHRAE Standard 55-2004) and acceptable indoor air quality (as required by ASHRAE Standard 62.1-2004, whether natural or mechanical ventilation).

SS	WE	EA	MR	EQ	ID
Credit 6					

1 point



Can assist tenants in certification under LEED for Commercial Interiors

SS	WE	EA	MR	EQ	ID
Credit 6					

Summary of Referenced Standards

ANSI/ASHRAE Standard 62.1-2004: Ventilation for Acceptable Indoor Air Quality

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org

(800) 527-4723

Section 5.1 (Natural Ventilation) of the standard provides minimum requirements for operable openings. The portion of the window that can be opened must be 4% of the net occupiable floor area. The means to open the windows must be readily accessible to building occupants.

ANSI/ASHRAE Standard 55-2004: Thermal Environmental Conditions for Human Occupancy

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org

(800) 527-4723

Standard 55-2004 identifies the factors of thermal comfort and the process for developing comfort criteria for a building space and the occupants of that space. “This standard specifies the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space. The environmental factors addressed are temperature, thermal radiation, humidity, and air speed; the personal factors are those of activity and clothing.” (ASHRAE)

Approach and Implementation

Conventional buildings too frequently are built as sealed space where the occupants have no control. A more desirable approach provides individuals the

controls to adjust the thermal conditions for a more comfortable environment. The components of an individual’s thermal comfort include air temperature and velocity, the amount of outside air and moisture content.

The design team should determine the level of individual control desired. Design the building with comfort controls to suit both individual needs and those of groups in shared spaces.

Strategies to consider include designs with operable windows, hybrid designs incorporating operable windows and mechanical systems, or mechanical systems alone. Individual control of comfort with mechanical systems may be integrated into the overall systems design by enabling individual adjustment of selected comfort parameters, such as individual thermostats, individual diffusers (located at floor, desk or overhead), and individual radiant panels. Occupancy sensors can also be integrated in the design to automatically turn down the thermostat and reduce airflow when occupants are away, helping reduce energy use.

Occupants must be educated on individual control of their office space environment. Additionally, key maintenance staff must be trained in the operations of the HVAC equipment and any installed controls.

Core and Shell Considerations

Core and shell HVAC system designs are typically incomplete; there are no occupants to design for. The intent of this credit in the core and shell rating system is to provide building HVAC systems that can be expanded to allow for a high degree of occupant control. Some system types make this credit easier to achieve and document than others. An under-floor air system that allows tenants to use individual diffusers is one of these system types. Buildings that use an overhead VAV system, will have to demonstrate that it is possible for the system to provide enough control points for 50% of the occupants.

SS	WE	EA	MR	EQ	ID
Credit 6					

Calculations

Individual Thermal Comfort

To determine if a project has met the requirements of this credit, the project team must first calculate the expected occupancy of the building. The default occupancy numbers in Appendix 1 may be used for this. The next step is to determine the number of controls that the HVAC system can support. This credit is achieved if the system can support enough controls for 50% of the occupants calculated above.

Operable windows may be used in lieu of individual controls for those occupants located within 20 ft. of the exterior wall and within 10 ft. of either side of the operable part of the window. The operable portion of the window will need to comply with the free-opening size criteria of ASHRAE Standard 62.1-2004 Section 5.1. The minimum area of the window opening may be 4% of the net occupiable area for the ventilation purposes, however larger opening areas may be required for thermal comfort over a wide range of outside conditions. Based on the limits used in this credit, for an area 20 ft. by 20 ft. per window, the opening size would need to be 16 sq.ft.

Shared Multi-Occupant Spaces

Buildings designed for shared multi-occupant spaces, such as retail complexes, must provide control to each space. To satisfy the requirement for these types of buildings, start by identifying those areas where transient groups share spaces, such as retail sales floors. Specific types or numbers of controls are not listed in the credit requirements to allow for flexibility in designing to the unique uses of each project. Confirm that there is at least one means of control over thermal comfort that is accessible to employees.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide the number of expected occupants on a floor-by-floor basis. See Appendix 1 for the default occupancy counts. State which systems serve each floor.
- Provide a narrative describing the project's comfort control strategy. Include data regarding the type of controls available to tenants. State the maximum number of controls allowed for each system. Demonstrate that 50% of the occupants can be served by the controls (or one control per multi-occupant space). For buildings with operable windows, determine

SS	WE	EA	MR	EQ	ID
Credit 6					

the number of occupants that could be located within 20 ft. of the exterior wall and within 10 ft. of either side of the operable part of the window. The operable windows may count as the control for these occupants.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is available to core and shell projects that incorporate into tenant sales or lease agreements language that requires compliance with this credit as part of the tenant scope of work. Provide the LEED letter template for the credit pursued indicating the following:

- 100% of leased square footage is required to comply with credit requirements. Lease or sales agreements may be requested.
- 100% of the unleased square footage shall comply with the credit requirements when leased. A statement signed by the owner/developer that all leases and/or sales agreements will comply may be requested.

Considerations

Cost Issues

The most frequently reported occupant complaints involve thermal discomfort. Greater thermal comfort may increase occupant performance and attendance and, at least, will reduce complaints. According to the Rocky Mountain Institute's Green Developments: Integrating Ecology and Real Estate, office worker salaries are estimated to be 72 times higher than energy costs, and they account for 92% of the life-cycle costs of a building; with this in mind, thermal comfort can have a tremendous effect on overall costs. As noted in a report published by the Center for the Built Environment ("Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building" by Fred S.

Bauman, PE – 1999) studies have shown that individual occupant controls can potentially increase the satisfaction and productivity of occupants. The financial implications of such improvements can be extremely large for building owners. Additional controllability may add to first costs of a project, however, these costs are generally offset by energy savings through lower conditioned temperatures, natural ventilation and less solar gain through proper use of shading devices. Conversely, abuse of personal controls such as setting thermostats too high or leaving windows open during non-working hours increases energy costs. Therefore, it is important to educate occupants on the design and function of system controls.

Alteration of the ventilation and temperature scheme may change the energy performance of the building and may require commissioning and Measurement & Verification attention. Controllability of systems may not be possible for occupants of existing buildings that are being rehabilitated, especially with regard to operable windows. The degree of occupant controls will affect the performance of the ventilation system. Daylighting and view strategies are affected by the controlling requirements of the operable windows in this credit.

Regional Issues

Local weather and ambient air conditions must be considered when determining the feasibility of operable windows for projects. For example, in areas that are prone to extreme temperatures for a majority of the year, or urban areas where traffic and air pollution are problematic, operable windows may not be an appropriate addition to a building.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific

resources on materials sources and other technical information.

Websites

Center for the Built Environment

www.cbe.berkeley.edu

This University of California, Berkeley Center for Environmental Design Research provides information on under-floor air distribution technologies and other topics. See the publications page for articles such as “A Field Study of PEM (Personal Environmental Module) Performance in Bank of America’s San Francisco Office Buildings.”

“Do Green Buildings Enhance the Well-being of Workers? Yes”

Environmental Design + Construction

<http://www.edcmag.com/CDA/Archives/fb077b7338697010VgnVCM100000f932a8c0>

An article by Judith Heerwagen in the July/August 2000 edition, of *Environmental Design + Construction* quantifies the effects of green building environments on productivity.

Print Media

Controls and Automation for Facilities Managers: Applications Engineering by Viktor Boed, CRC Press, 1998.

Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building by Fred S. Bauman, PE, Center for the Built Environment, 1999.

Using advanced office technology to increase productivity: the impact of environmentally responsive workstations (ERWs) on productivity and worker attitude by W. Kroner, J. Stark-Martin and T. Willemain. The Center for Architectural Research, Rensselaer Polytechnic Institute, Troy, New York, 1992.

Definitions

Shared (Group) Multi-Occupant Spaces include retail sales floors.

Individual Occupant Spaces are typically private offices and open office plans with workstations.

Non-Occupied Spaces include all rooms used by maintenance personnel that are not open for use by occupants. Included in this category are janitorial, storage and equipment rooms and closets.

Non-Regularly Occupied Spaces include corridors, hallways, lobbies, break rooms, copy rooms, storage rooms, kitchens, restrooms, stairwells, etc.

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Credit 6					

Thermal Comfort

Design

Intent

Provide a comfortable thermal environment that supports the productivity and well-being of building occupants.

Requirements

Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy. Demonstrate design compliance in accordance with the Section 6.1.1 Documentation.

See Appendix 1 – Default Occupancy Counts for occupancy count requirements and guidance.

The core and shell base building mechanical system must provide the capability for the tenant build-out to meet the requirements of this credit.

Core and shell buildings designed for mechanical ventilation that do not purchase and/or install the mechanical system can not achieve this credit.

Potential Technologies & Strategies

Establish comfort criteria per ASHRAE Standard 55-2004 that support the desired quality and occupant satisfaction with building performance. Design building envelope and systems with the capability to deliver performance to the comfort criteria under expected environmental and use conditions. Evaluate air temperature, radiant temperature, air speed, and relative humidity in an integrated fashion and coordinate these criteria with EQ Prerequisite 1, EQ Credit 1 and EQ Credit 2.

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Credit 7					

1 point



SS	WE	EA	MR	EQ	ID
Credit 7					

Summary of Referenced Standards

ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.com

(800) 527-4723

“This standard specifies the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space. The environmental factors addressed are temperature, thermal radiation, humidity, and air speed; the personal factors are those of activity and clothing.” (ASHRAE)

Approach and Implementation

If properly designed, built and operated, a green building provides its occupants with comfortable indoor conditions that support their productivity and well-being. Although often associated only with air temperature, thermal comfort is a complex issue, impacted by environmental conditions (air temperature, radiant temperature, humidity and air speed) and personal factors (metabolic rate and clothing level) as well as personal preferences of occupants.

Strategies

There are three basic approaches to providing thermal comfort within a project space:

- Active Conditioning (e.g. mechanical HVAC systems)
- Passive Conditioning (e.g. natural ventilation)
- Mixed-mode conditioning—employing a combination of active and passive systems

The owner and project team should make a decision as to which of the conditioning approaches are appropriate for the building. ASHRAE Standard 55-2004 provides thermal comfort standards, with an optional alternate approach specifically for naturally ventilated spaces.

ASHRAE 55-2004 is based on the Predicted Mean Vote (PMV) comfort model which incorporates heat balance principles to relate the personal and environmental thermal comfort factors based on the thermal sensation scale that shows seven levels ranging from +3 (hot) to -3 (cold). The PMV model is applicable to air speeds not greater than 0.20 m/s (40 fpm).

For naturally ventilated spaces, the standard notes that field experiments have shown that occupants’ thermal responses depend in part on the outdoor climate and may differ from thermal responses in buildings with centralized HVAC systems. This is primarily because of the different thermal experiences, changes in clothing, availability of control, and shifts in occupant expectations. The standard provides an optional method of compliance, intended for naturally ventilated spaces. This optional method (Section 5.3 of the standard) provides broad indoor temperature ranges as a function of mean monthly outdoor temperatures; assuming light, sedentary activity but independent of humidity, air speed and clothing considerations.

Planning & Design Phase

Using ASHRAE Standard 55-2004, the design team and the owner in collaboration should identify the environmental parameters required to maintain the desired thermal comfort in the project space and then identify the conditioning systems (whether active or passive) that can best provide these conditions. This decision may be influenced by the size, type, location, and climatic conditions of the proposed building as well as the

SS	WE	EA	MR	EQ	ID
Credit 7					

nature of the operations that will occur in the building.

There are many well established HVAC load calculation methodologies to assist designers in sizing and selecting HVAC equipment in order to provide thermal comfort conditions. Lighting systems and other internal HVAC loads are integrated into the HVAC sizing calculations, to allow for adequate system capacity to meet thermal comfort criteria without over-sizing the HVAC systems.

A natural ventilation approach may be more difficult to evaluate in design and require more intensive analysis and/or reliance on experience and precedents. For naturally ventilated buildings CIBSE AM10 presents design strategies for comfortable and healthy naturally ventilated buildings.

Operation Phase

For mechanical conditioning, the operating setpoints and parameters of the HVAC system will be a primary influence on thermal comfort conditions in the project space. Many facility operators in mechanically air-conditioned spaces spend significant effort and time adjusting thermostat setpoints and other operational parameters in order to limit complaints associated with poor thermal comfort. Systems where individual occupants are provided some amount of direct control over temperature and/or air movement generally yield fewer thermal comfort complaints.

The maxim “passive buildings, active occupants” fits the natural ventilation model well. Occupants generally take a primary role in managing thermal comfort conditions in naturally ventilated buildings by opening and closing windows as necessary and appropriate. Thermal comfort in naturally conditioned buildings is also somewhat more variable and tied to the ambient conditions than in mechanically conditioned buildings where systems are

often designed to maintain relatively consistent conditions throughout all periods of occupancy.

Core and Shell Considerations

Core and shell HVAC system designs are typically incomplete: there are no occupants to design for. The intent of this credit in the core and shell rating system is to furnish building HVAC systems that provide a thermally comfortable environment. To achieve this credit, projects must demonstrate that the core and shell systems are designed to maintain the tenant spaces at the thermal comfort conditions detailed in ASHRAE 55-2004.

Calculations

There are no calculations required for this LEED-CS credit. However, project teams should be able to describe how thermal comfort conditions were established for the project and how the design of conditioning systems addresses the thermal comfort design criteria.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

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Credit 7					

Certification Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Provide data regarding seasonal temperature and humidity design criteria.
- Provide a narrative describing the method used to establish the thermal comfort conditions for the project and how the systems design addresses the design criteria. Include specific information regarding compliance with the referenced standard.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is available to core and shell projects that incorporate into tenant sales or lease agreements language that requires compliance with this credit as part of the tenant scope of work. Provide the LEED letter template for the credit pursued indicating the following:

- 100% of leased square footage is required to comply with credit requirements. Lease or sales agreements may be requested.
- 100% of the unleased square footage shall comply with the credit requirements when leased. A statement signed by the owner/developer that all leases and/or sales agreements will comply may be requested.

Considerations

Environmental Issues

Building conditioning systems, including both active HVAC systems and natural ventilation systems, are designed and

installed in buildings to enhance thermal comfort for building occupants. These building conditioning systems may serve other functions as well, including providing ventilation air and providing thermal conditioning for equipment and processes. Designing and installing building conditioning systems to provide superior thermal comfort, ventilation, and indoor air quality as efficiently, and cost effectively as possible is a central challenge for many green building projects

Synergies and Trade-Offs

An active HVAC system generally will provide a higher degree of control over indoor thermal comfort conditions than a passive conditioning system. Capital, energy and lifecycle costs, however, are generally higher for an active HVAC system than for a naturally ventilated system.

Natural ventilation and other passive conditioning approaches are often dependent on occupants' managing the system (e.g. opening windows or closing blinds at appropriate times) to meet the comfort criteria. Active conditioning systems generally rely on central automation systems to comply with little or no direct occupant control.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Enhance Indoor Environmental Quality (IEQ)

The Whole Building Design Guide

www.wbdg.org/design/ieq.php

The Indoor Environmental Quality section provides a wealth of resources including definitions, fundamentals, materials and tools.

Print Media

ASHRAE Standard 62.1-2004: Ventilation for Acceptable Indoor Air Quality, ASHRAE, 2004.

Humidity Control Design Guide by L. Harriman, G.W. Brundett and R. Kittler, ASHRAE, 2000.

The Impact of Part-Load Air-Conditioner Operation on Dehumidification Performance: Thermal Comfort by P.O. Fanger, Mc-Graw Hill, 1973.

Thermal Delight in Architecture by Lisa Heschong, MIT Press, 1979.

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Definitions

Natural Ventilation is the ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building (ASHRAE 62.1-2004).

Relative Humidity is the ratio of partial density of water vapor in the air to the saturation density of water vapor at the same temperature and the same total pressure (ASHRAE 55-2004).

Thermal Comfort is a condition of mind experienced by building occupants expressing satisfaction with the thermal environment.

Comfort Criteria is specific original design conditions that shall at minimum include temperature (air, radiant and surface), humidity and air speed as well as outdoor temperature design conditions, outdoor humidity design conditions, clothing (seasonal) and activity expected (ASHRAE 55-2004).

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Credit 7					

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Credit 8.1					

Daylight and Views

Daylight 75% of Spaces

Intent

Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Requirements

OPTION 1 — GLAZING FACTOR CALCULATION

Achieve a minimum glazing factor of 2% in a minimum of 75% of all regularly occupied areas. The glazing factor is calculated as follows:

$$\text{Glazing Factor} = \frac{\text{Window Area [SF]}}{\text{Floor Area [SF]}} \times \text{Window Geometry Factor} \times \frac{\text{Actual } T_{\text{vis}}}{\text{Minimum } T_{\text{vis}}} \times \text{Window Height Factor}$$

OR

OPTION 2 — DAYLIGHT SIMULATION MODEL

Demonstrate, through computer simulation, that a minimum daylight illumination level of 25 footcandles has been achieved in a minimum of 75% of all regularly occupied areas. Modeling must demonstrate 25 horizontal footcandles under clear sky conditions, at noon, on the equinox, at 30" above the floor.

OR

OPTION 3 — DAYLIGHT MEASUREMENT

Demonstrate, through records of indoor light measurements, that a minimum daylight illumination level of 25 footcandles has been achieved in at least 75% of all regularly occupied areas. Measurements must be taken on a 10-foot grid for all occupied spaces and must be recorded on building floor plans.

OR

OPTION 4 — PRESCRIPTIVE

Use a combination of side-lighting and top-lighting to achieve a total Daylighting Zone (floor area meeting the following requirements) that is at least 75% of all the regularly occupied spaces.

Sidelighting Daylight Zone:

- Achieve a product of the visible light transmittance (VLT) and window to floor area ratio (WFR) of daylight zone between the values of 0.150 and 0.180. Window area included in the calculation must be of the portion of the window at least 2'-6" above the floor.

$$0.150 < \text{VLT} \times \text{WFR} < 0.180$$

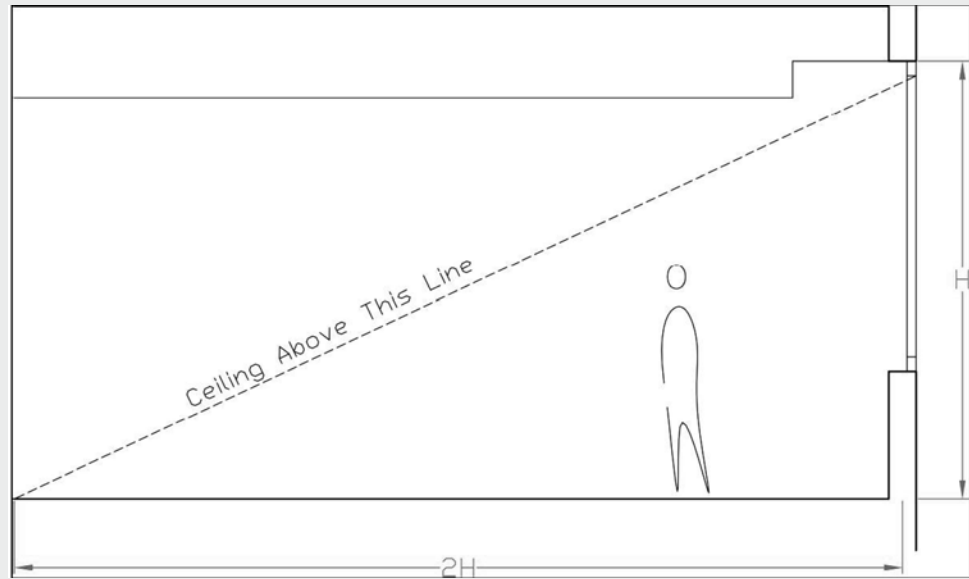
1 point



Can assist tenants in certification under LEED for Commercial Interiors

- In section, ceiling should not obstruct a line that joins the window-head to a line on the floor that is parallel to the plane of the window and is, in distance from the plane of the glass as measured perpendicular to the plane of the glass, two times the height of the window head above the floor. See **Figure 1**.
- Provide sunlight redirection and/or glare control devices to ensure daylight effectiveness.

Figure 1: Sidelighting Daylight Zone



Toplighting Daylight Zone:

- The daylight zone under a skylight is the outline of the opening beneath the skylight, plus in each direction the lesser of: 70% of the ceiling height, one half of the distance to the edge of the nearest skylight, or the distance to any permanent opaque partition (if transparent, show VLT) which is farther away than 70% of the distance between the top of the partition and the ceiling. See **Figure 2**.
- Achieve a skylight roof coverage that is between 3% and 6% of the roof area with a minimum 0.5 visible light transmittance (VLT) for the skylights.
- The distance between the skylights shall not be more than 1.4 times the ceiling height.
- Provide a skylight diffuser with a measured haze value of greater than 90% when tested according to ASTM D1003. Avoid direct line of sight to skylight diffuser.

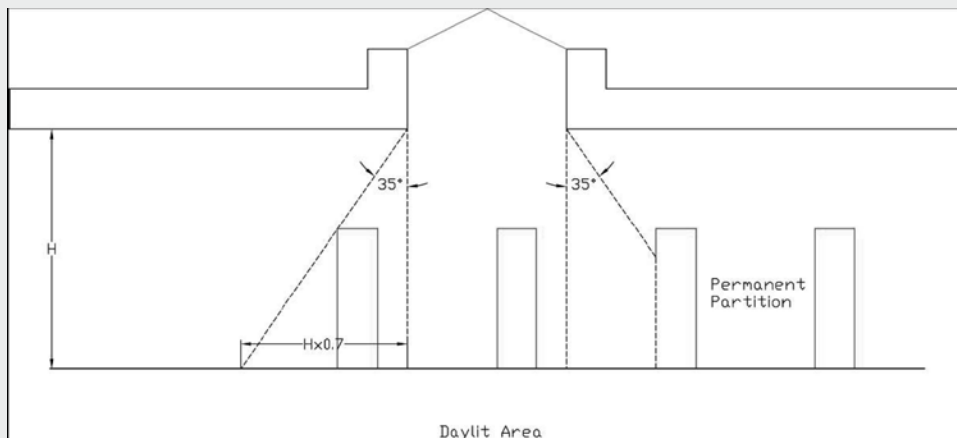
Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

Figure 2: Toplighting Daylight Zone

In all cases, only the square footage associated with the portions of rooms or spaces meeting the minimum illumination requirements can be applied towards the 75% of total area calculation required to qualify for this credit.

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Figure 2: Toplighting Daylight Zone



In all cases, provide daylight redirection and/or glare control devices to avoid high-contrast situations that could impede visual tasks. Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

Potential Technologies & Strategies

Design the building to maximize interior daylighting. Strategies to consider include building orientation, shallow floor plates, increased building perimeter, exterior and interior permanent shading devices, high performance glazing and automatic photocell-based controls. Predict daylight factors via manual calculations or model daylighting strategies with a physical or computer model to assess footcandle levels and daylight factors achieved.

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Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

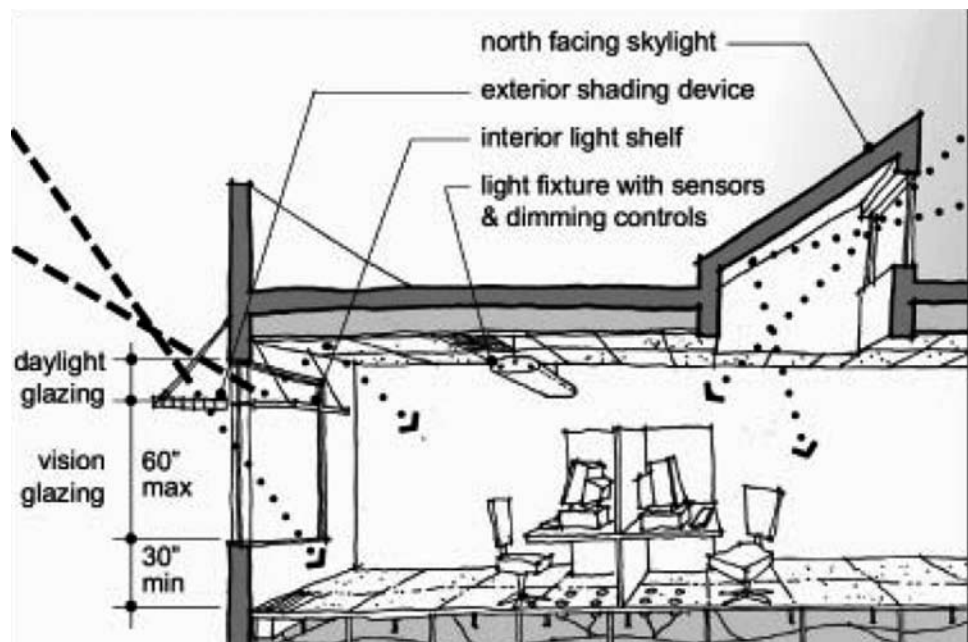
A building may have limited daylighting potential due to site or program constraints that limit the orientation of the building, number and size of building openings and floor plate dimensions. Vertical site elements such as neighboring buildings and trees may reduce the potential for daylighting. Evaluate the impact of the building's orientation on possible daylighting options; strive to incorporate shallow floor plates, courtyards, atriums, clerestory windows and skylights into the project to increase daylighting potential. Evaluate the potential to add interior light shelves, exterior fins, louvers and adjustable blinds. See **Figure 3**, which illustrates various daylighting strategies. Glazing parameters directly affect the heat gain and loss of the building which may result in increased energy use. It is

important to address the glazing properly not only for energy usage but also for visual quality.

The desired amount of daylight will differ depending on the tasks occurring within each program space. Daylit spaces often have several daylight zones with differing target light levels. In addition to light levels, daylighting strategies should address interior color schemes, direct beam penetration and integration with the electric lighting system. Glare control is perhaps the most common failure in daylighting strategies. Glare is defined as any excessively bright source of light within the visual field that creates discomfort or loss in visibility. Large window areas provide generous amounts of daylight to the task area. If not controlled properly, this daylight can produce unwanted glare and affect the lighting quality. Measures to control glare include light shelves, louvers, blinds, fins and shades. Typically, low luminance ratios and lighting of primary surfaces will enhance visual quality.

Computer modeling software can be used to simulate daylighting conditions and to provide valuable input into the

Figure 3: An illustration of Various Daylighting Strategies



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Credit 8.1					

development of an effective, integrated daylighting strategy. Daylighting software produces continuous daylight contours to simulate the daylighting conditions of interior spaces and to account for combined effects of multiple windows within a daylit space.

Photo-responsive controls for electric lighting can be incorporated into daylighting strategies to maintain consistent light levels and to minimize occupant perception of the transition from natural light to artificial light. These controls result in energy savings by reducing electric lighting in high daylight conditions while preserving footcandle levels on the task surface. These types of automatic controls require commissioning and also Measurement & Verification attention.

Core and Shell Considerations

Core and shell building designs typically do not include interior partitions except for those that enclose core spaces. This credit may seem highly achievable for a building with a wide-open floor plate, but this credit is dependant on more than that. The design of the exterior envelope and the depth of the floor plate are also critical for credit achievement. The core and shell project team directly affects the ability of the tenants to accomplish and optimize daylighting of their spaces. Decisions made by the core and shell team can preclude the tenant from achieving this credit in LEED-CI.

Calculations

Compliance with the requirements for this credit may be determined by either following the Glazing Factor calculation methodology (outlined in the following paragraphs) to determine overall glazing factor, or by using daylighting simulation software to determine point-by-point illumination levels (footcandles) measured at desk height (30" above the finished floor).

Areas to include in the daylighting calculations are all areas that could be used as regularly occupied space. Areas that should not be considered include support areas for elevator lobbies, storage, mechanical equipment and restrooms.





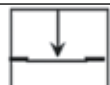
The calculation methodology below can be applied to approximate the Glazing Factor for each regularly occupied area in the building. The Glazing Factor (GF) is the ratio of exterior illumination to interior illumination and is expressed as a percentage. The variables used to determine the daylight factor include the floor area, window area, window geometry, visible transmittance (T_{vis}) and window height. This calculation method aims to provide a minimum 2% GF at the back of a space. The Glazing Factor calculation method is designed to identify daylighting conditions based on room and window geometry and visible transmittance based on meeting the performance criteria for overcast sky conditions. Currently this calculation method doesn't take into account light shelves, partitions, significant exterior obstructions or exterior reflective surfaces.

The development of a Daylight Simulation Model is highly recommended where daylighting strategies go beyond the current capability to the Glazing Factor Calculation Method.

Option 1—Glazing Factor

1. Create a spreadsheet and identify all areas that could be regularly occupied. It may be necessary to divide up the floor plate into smaller areas. Determine the floor areas using the construction documents.
2. For each area identified, calculate the window area and use **Table 1** to indicate the acceptable window types. Note that window areas above 7'6" are considered to be daylight glazing. Glazing at this height is the most effective at distributing daylight deep into the interior space. Window areas

Table 1: Daylight Design Criteria

Window Type	Geometry Factor	Minimum T _{vis}	Height Factor	Best Practice Glare Control
 sidelighting daylight glazing	0.1	0.7	1.4	Adjustable blinds Interior light shelves Fixed translucent exterior shading devices
 sidelighting vision glazing	0.1	0.4	0.8	Adjustable blinds Exterior shading devices
 toplighting vertical monitor	0.2	0.4	1.0	Fixed interior Adjustable exterior blinds
 toplighting sawtooth monitor	0.33	0.4	1.0	Fixed interior Exterior louvers
 toplighting horizontal skylights	0.5	0.4	1.0	Interior fins Exterior fins Louvers

from 2'6" to 7'6" are considered to be vision glazing. These window areas are primarily used for viewing and lighting interior spaces close to the building perimeter. Window areas below 2'6" do not contribute to daylighting of interior spaces and are to be excluded from the calculations.

- For each window type, insert the appropriate geometry and height factors as listed in **Table 1**. The geometry factor indicates the effectiveness of a particular aperture to distribute daylight relative to window location. The height factor accounts for where light is introduced to the space.
- For each window type, indicate the visible transmittance (T_{vis}), a variable number that differs for each product. Minimum T_{vis} is the recommended level of transmittance for selected glazing.
- Calculate the Glazing Factor for each window type using **Equation 1**. For rooms/areas with more than one window type, sum all window types to obtain a total Glazing Factor for the room/area.
- If the total Glazing Factor for a room/area is 2% or greater, then the square footage of the room/area is applicable to the credit.

Equation 1: Glazing Factor Calculation

$$\text{Glazing Factor} = \frac{\text{Window Area [SF]}}{\text{Floor Area [SF]}} \times \text{Window Geometry} \times \frac{\text{Actual } T_{vis}}{\text{Minimum } T_{vis}} \times \text{Window Height Factor}$$

- Sum the square footage of all applicable rooms/areas and divide by the total square footage of all regularly occupied spaces. If this percentage is equal to or greater than 75%, then the project qualifies for this point. (See **Note 1** for further information.)
- Note that glare control is also required for each window. **Table 3** provides best-practice glare control measures for different window types.

Table 2 provides an example of daylighting calculations for a typical office space. All of the offices are considered to be regularly occupied spaces, while support areas such as hallways, foyers, storage areas, mechanical rooms and restrooms are not considered to be regularly occupied. The example qualifies for this credit because it exceeds the minimum square footage percentage for daylit areas and includes glare control on all windows in daylit rooms.

Option 2—Daylight Simulation Model

- Create a daylight simulation model for the building, or each regularly

occupied space with glazing. The model should include appropriate glazing factors as well as representative surface reflectance settings for interior finishes.

- For each applicable area, include a horizontal calculation grid at 30” above the floor. This grid will represent the typical work plane height. The calculation grid should be set at approximately 2 foot intervals to provide a detailed illumination diagram for each area. (For larger areas, it may be necessary to increase the grid size for clarity.)
- Calculate the daylight illumination for each applicable space using the following daylight criteria: clear sky conditions at 12:00 noon on the equi-

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Credit 8.1					

Table 3: Common Glare Control Strategies

Description
Fixed Exterior Shading Devices
Light Shelf, Exterior
Light Shelf, Interior
Interior Blinds or Pull-Down Shade
Fritted Glazing
Drapes
Electronic Black-Out Glazing

Table 2: Glazing Factor Tabulation Spreadsheet

Regularly Occupied Space ID	Regularly Occupied Space Name	Regularly Occupied Space Area (sf)	Sidelighting - Vision Glazing					Sidelighting - Daylight Glazing					Glazing Factor
			Geometry Factor	Area (sf)	Actual T _{vis}	Min T _{vis}	Height Factor	Geometry Factor	Area (sf)	Actual T _{vis}	Min T _{vis}	Height Factor	
75% of total regularly occupied floor area	Open Office (Compliance Required Area)	12,600	0.10	2,280	0.9	0.4	0.8	0.10	1,140	0.9	0.7	1.4	2.04
25% of total regularly occupied floor area	Open Office (non-daylit Area)	4,200	NA	0	NA	NA	NA	NA	0	NA	NA	NA	0

Total Regularly Occupied Space Area (sf)	Total Regularly Occupied Space Area with a Minimum 2% Glazing Factor	Percentage of Regularly Occupied Space with a 2% Glazing Factor
4585	3570	78%

SS	WE	EA	MR	EQ	ID
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nox (March 21/September 21) for the project's specific geographic location. **Figure 4** illustrates a sample daylight analysis for an office space.

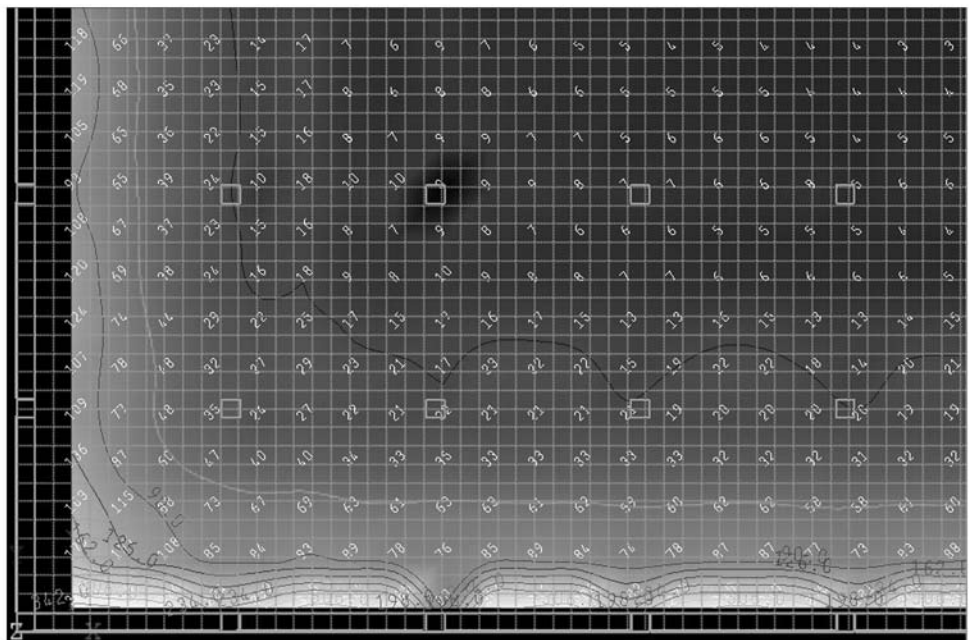
4. Create a spreadsheet and identify all regularly occupied areas. Determine the floor area of each applicable area using construction documents. Provide the minimum illumination level (footcandles), determined through the simulation model, for each space.
5. If the minimum illumination for a room/area is 25 footcandles or greater, then the square footage of the room/area is applicable to the credit. (See **Note 1** for further information.)
6. Sum the square footage of all daylit rooms/areas and divide by the total square footage of all regularly occupied spaces. If this percentage is equal to or greater than 75%, then the project qualifies for one point under this Credit.
7. Note that glare control is also required for each window. **Table 1** provides best-practice glare control measures for different window types. Create

another spreadsheet entry that identifies the type of glare control applied to each window type. The type of glare control selected for each window does not affect the daylight factor calculations. **Table 3** provides a listing of common glare control strategies.

Option 3—Daylight Measurement

NOTE 1: This credit can be approached so that 100% of each space does not have to meet the 2% daylight factor or the minimum 25 footcandle requirement. In order to do so, the portion of the space with a 2% (or higher) daylight factor, or 25 footcandle minimum illumination, would count towards the percentage of all space occupied for critical visual tasks. The portion of the space not meeting the daylight factor or illumination criteria would not count towards the compliant area total, but would be considered in the total area calculation. For the calculation spreadsheet, the two portions of the room (the one meeting the minimum daylight factor or illumination and the one not meeting the requirements) would be counted as separate spaces (See **Table 2**).

Figure 2: Sample Daylight Simulation Model Output



The square footage of all compliant spaces is tallied and then divided over the total square footage of all regularly occupied spaces. If the percentage is equal to or greater than 75%, then the project qualifies for one point under this Credit.

Option 4—Prescriptive

Sidelighting

The purpose of this option is to provide projects with a relatively simple method of ensuring that the daylighting credit is met. This method is applicable for relatively standard building designs, primarily rectangular floor plates with a central core. The project team will need to know basic information regarding the building in order to determine compliance. This information is:

- Window head height
- Window sill height
- Window width (per bay)
- Bay width
- Bay depth to core
- VLT (T_{vis})

The calculation should be done for each bay condition in the building (north/south, east/west and corner). The following steps should be used:

1. Determine WA: the Window Area for the bay. This is the window head height

less the window sill height that is 2'-6" or greater above the floor, multiplied by the window width(s) per bay.

2. Determine FA: the Floor Area (FA) for the typical bay. This is the bay width times the bay depth to core.
3. Determine WFR: the ratio of the Window Area to the Floor Area and is expressed as WA/FA
4. Determine (VLT) (WFR): this is the ratio of visible light transmittance to window to floor area and is expressed as (VLT) (WFR)
5. If this number is between 0.150 and 0.180, the credit has been met for the bay.
6. Each bay condition in the building must meet this requirement.

An example of this calculation is shown below.

Toplighting Daylight Zone

This method is applicable for relatively standard building designs, and may be particularly useful for single floor retail developments. The project team will need to know the following basic information regarding the building in order to determine compliance.

- Area of skylights (SA)
- VLT (T_{vis}) of skylights

Example Calculation

	N/S bay	E/W bay	Corner bay
Window head height	10	10	10
Window sill height	2.5	2.5	2.5
Window width (per bay)	19	19	78
Bay width	20	20	40
Bay depth to core	40	40	40
VLT (T_{vis})	0.86	0.86	0.45
WA			
Window daylight height	7.5	7.5	7.5
Window area (WA)	142.5	142.5	585
FA			
Floor area (FA)	800	800	1600
WFR = (WA/FA)	0.178125	0.178125	0.365625
(VLT) (WFR)	0.1531875	0.1531875	0.16453125

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- Roof area (RA)
- Distance between skylights
- Measured haze value of skylight diffuser

The calculation should be done for a typical building condition using the following steps:

1. Determine the skylight roof coverage – this is the ratio of area of skylights to area of roof and is expressed by (SA/RA) (100).
2. Confirm that the skylight diffuser is greater than 90%.
3. Determine the daylight zone(s) in square feet below the skylight, based on the prescriptive criteria.
4. Evaluate the total area (in square feet) of the daylight zone(s).
5. If this total area is 75% or greater than the area of the regularly occupied spaces in the building, the credit has been met.

Combined Sidelighting and Toplighting Daylight Zone

For buildings that have both sidelighting and toplighting conditions a combination of the above two methodologies can be utilized to demonstrate compliance.

Exemplary Performance

This credit may be eligible for exemplary performance under the Innovation & Design section if the project achieves 95% daylighting based on the requirements and guidelines of this credit.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit

requirements on the credit-specific Submittal Template signed by the appropriate design team member

- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

Glazing Factor Calculation Method

- Complete the template calculation spreadsheet to demonstrate overall Glazing Factor. The following data is required for input in the template: occupied space area (sq.ft.); area of each type of glazing (sidelighting and toplighting); and visible light transmittance (T_{vis}) for each glazing type.

OR

Computer Simulation Method

- Complete the template calculation spreadsheet to demonstrate that the project complies with the minimum illumination levels. The following data is required for input in the template: total regularly occupied space area (sq.ft.); and total regularly occupied space area that achieves a simulated minimum of 25 footcandles.

- Provide copies of the applicable project drawings showing the illumination simulation results.

OR

Daylight Measurement Method

- Complete the template calculation spreadsheet to demonstrate that the

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project complies with the minimum illumination levels. The following data is required for input in the template: total regularly occupied space area (sq.ft.); and total regularly occupied space area that achieves a measured minimum of 25 footcandles.

- Provide copies of the applicable project drawings showing the illumination simulation results.

OR

Prescriptive Method

- Complete the template calculation spreadsheet to demonstrate that the project complies with the minimum illumination levels; that the Sidelighting and Toplighting conditions evaluated constitutes 75% or greater of the building's regularly occupied spaces; and that the applicable prescriptive conditions for Sidelighting and Toplighting have been met.
- Provide a typical floor plan drawing with an indication of the typical bay condition that has been evaluated.
- Provide a typical floor plan drawing with an indication of the skylight condition that has been evaluated.

AND

- Provide a narrative describing any special occupancy areas that have been excluded from compliance. The narrative should include a detailed description of the space function and an explanation as to why the inclusion of views would hinder the normal tasks/function of each excluded area.

For projects that have used computer simulation or physical measurements, please include detailed information describing the method used to determine the daylighting contributions in the building. Include specific information regarding the actual or simulated time of day and weather conditions, measurement equipment or software used, and

the calculation method for determining the final daylighting area.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Considerations

Cost Issues

Specialized glazing can increase initial costs for a project and can lead to excessive heat gain if not designed properly. Glazing provides less insulating effects compared to standard walls, resulting in higher energy use and requiring additional maintenance. However, offices with sufficient natural daylight have proven to increase occupant productivity and comfort. In most cases, occupant salaries significantly outweigh first costs of incorporating daylighting measures into a building design. Studies of schools and stores have shown that daylighting can improve student performance and retail sales (see the Resources section). Daylighting can significantly reduce artificial lighting requirements and energy costs in many commercial and industrial buildings, as well as schools, libraries and hospitals. Daylighting, combined with energy-efficient lighting and electronic ballasts, can reduce the lighting power density in some office buildings by up to 30%.

Environmental Issues

Daylighting reduces the need for electric lighting of building interiors, resulting in decreased energy use. A well-designed daylit building is estimated to reduce lighting energy use by 50 to 80% (Sustainable Building Technical Manual, chapter IV.7, page 90). This conserves natural resources and reduces air pollution impacts due to energy production and consumption.

Daylighting design involves a careful balance of heat gain and loss, glare control,

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visual quality and variations in daylight availability. Shading devices, light shelves, courtyards, atriums and window glazing are all strategies employed in daylighting design. Important considerations include the selected building's orientation, window size and spacing, glass selection, reflectance of interior finishes and locations of interior walls. Daylit spaces also increase occupant productivity and reduce absenteeism and illness.

Community Issues

Daylighting and outdoor views provide a connection with the building site and adjacent sites, creating a more integrated neighborhood. Daylit spaces can increase occupant productivity and reduce illness and absenteeism.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Analysis of the Performance of Students in Daylit Schools

www.innovativedesign.net/studentperformance.htm

Nicklas and Bailey's 1996 study of three daylit schools in North Carolina.

The Art of Daylighting

<http://www.edcmag.com/CDA/Archives/10e5869a47697010VgnVCM100000f932a8c0>

This *Environmental Design + Construction* article provides a solid introduction to daylighting.

New Buildings Institute's Productivity and Building Science Program

[www.newbuildings.org/downloads/FinalAttachments/PIER_Final_Report\(P500-03-082\).pdf](http://www.newbuildings.org/downloads/FinalAttachments/PIER_Final_Report(P500-03-082).pdf)

Provides case studies and program report on the benefits of daylighting.

Radiance Software

<http://radsite.lbl.gov/radiance/>

Free daylighting simulation software from the Lawrence Berkeley National Laboratory

The Whole Building Design Guide, Daylighting

www.wbdg.org/design/daylighting.php?r=ieq

Lighting Controls

www.wbdg.org/design/electriclighting.php?r=ieq

The Daylighting and Lighting Controls sections provide a wealth of resources including definitions, fundamentals, materials and tools.

Print Media

Architectural Lighting, Second Edition by M. David Egan, PE, and Victor Olgyay, AIA, McGraw-Hill, 2002.

"Daylighting Design" by Benjamin Evans, in *Time-Saver Standards for Architectural Design Data*, McGraw-Hill, Inc., 1997.

Daylighting for Sustainable Design by Mary Guzowski, McGraw-Hill, Inc., 1999.

Daylighting Performance and Design by Gregg D. Ander, John Wiley & Sons, 1997.

Sustainable Building Technical Manual, Public Technology Institute, 1996.

(www.pti.org)

Definitions

Glazing Factor is the ratio of interior illuminance at a given point on a given plane (usually the work plane) to the exterior illuminance under known overcast sky conditions. LEED uses a simplified approach for its credit compliance calculations. The variables used to determine

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the daylight factor include the floor area, window area, window geometry, visible transmittance (T_{vis}) and window height.

Daylighting is the controlled admission of natural light into a space through glazing with the intent of reducing or eliminating electric lighting. By utilizing solar light, daylighting creates a stimulating and productive environment for building occupants.

Daylighting Zone is the total floor area that meets the performance requirements for daylighting.

Non-Occupied Spaces include all rooms used by maintenance personnel that are not open for use by occupants. Included in this category are janitorial, storage and equipment rooms, and closets.

Non-Regularly Occupied Spaces include corridors, hallways, lobbies, break rooms, copy rooms, storage rooms, kitchens, restrooms, stairwells, etc.

Regularly Occupied Spaces are areas where workers are seated or standing as they work inside a building; in residential applications it refers to living and family rooms.

Visible Light Transmittance (T_{vis}) is the ratio of total transmitted light to total incident light. In other words, it is the amount of visible spectrum (380–780 nanometers) light passing through a glazing surface divided by the amount of light striking the glazing surface. A higher T_{vis} value indicates that a greater amount of visible spectrum incident light is passing through the glazing.

Window to Floor Area Ratio (WFR) is the total area of the window (measured vertically from 2'-6" (or greater) above finish floor to the top of the glass, multiplied by the width of the glass) divided by the floor area.

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Daylight & Views

Views for 90% of Spaces

Intent

Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Requirements

Achieve direct line of sight to the outdoor environment via vision glazing between 2'6" and 7'6" above finish floor for building occupants in 90% of all regularly occupied areas. Determine the area with direct line of sight by totaling the regularly occupied square footage that meets the following criteria:

- In plan view, the area is within sight lines drawn from perimeter vision glazing.
- In section view, a direct sight line can be drawn from the area to perimeter vision glazing.

Line of sight may be drawn through interior glazing. For private offices, the entire square footage of the office can be counted if 75% or more of the area has direct line of sight to perimeter vision glazing. For multi-occupant spaces, the actual square footage with direct line of sight to perimeter vision glazing is counted.

The core and shell design needs to develop a feasible tenant layout(s) per the default occupancy counts (or some other justifiable occupancy count) that can be used in the analysis of this credit.

Potential Technologies & Strategies

Design the space to maximize daylighting and view opportunities. Strategies to consider include lower partition heights, interior shading devices, interior glazing, and automatic photocell-based controls.

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1 point



Can assist tenants in certification under LEED for Commercial Interiors

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Credit 8.2					

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

There are two calculations required to determine achievement of this credit—Direct Line of Sight to Perimeter Glazing and Horizontal View. The Direct Line of Sight to Perimeter Glazing determination is an area calculation, and confirms that 90% of the occupied area is designed so there is the potential for views from regularly occupied areas. It is based on vision glazing (2'6" – 7'6"), and the location of full height interior partitions. Movable furniture and partitions are not included in the scope of this credit calculation. See **Figure 1**.

One successful design strategy for offices locates open plan areas along the exterior walls, while placing private offices and areas not regularly occupied to the core of the building. The Horizontal Views determination confirms that the available

views are maintained. It is recommended that the line of sight used for the determination of Horizontal Views is assumed to be 42" to reflect an average seated eye height. Design teams may, however, wish to utilize alternate view heights for areas with non-typical functions. Maintaining the views for spaces near the core is a primary design objective. See **Figure 2**.

Regularly occupied spaces include office spaces, conference rooms and cafeterias. Areas that need not be considered include support areas for copying, storage, mechanical equipment, laundry and restrooms.

Core and Shell Considerations

Because core and shell project scope would generally have no, or limited, interior build out as aprt of the project scope, the core and shell building design needs to be capable of being built-out by a tenant in such a way as to provide views for 90% of regularly occupied areas. The core and shell design team will need to test this with a feasible tenant layout for the

Figure 1: Direct Line of Sight to Perimeter Vision Glazing, used in the area determination

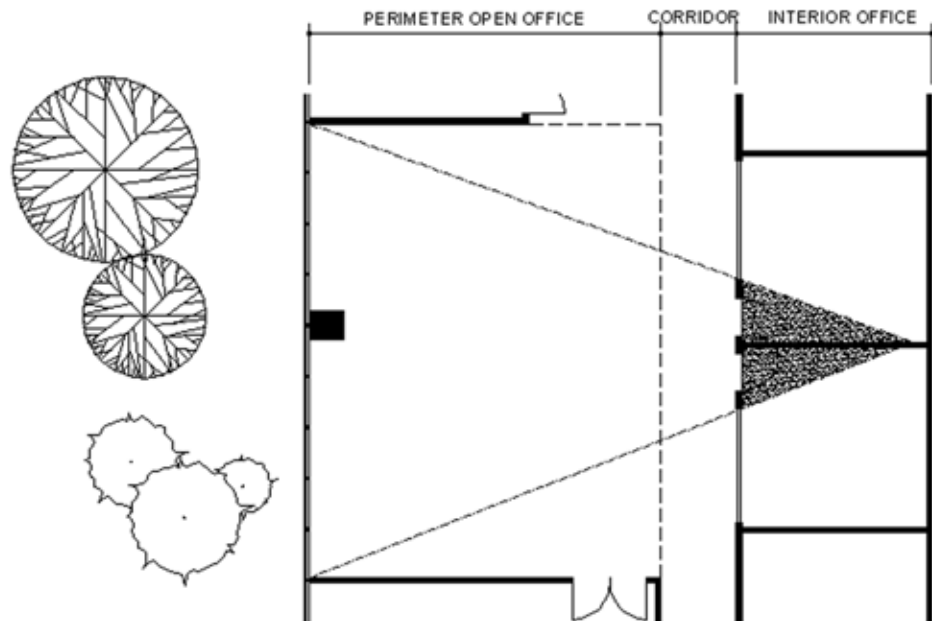
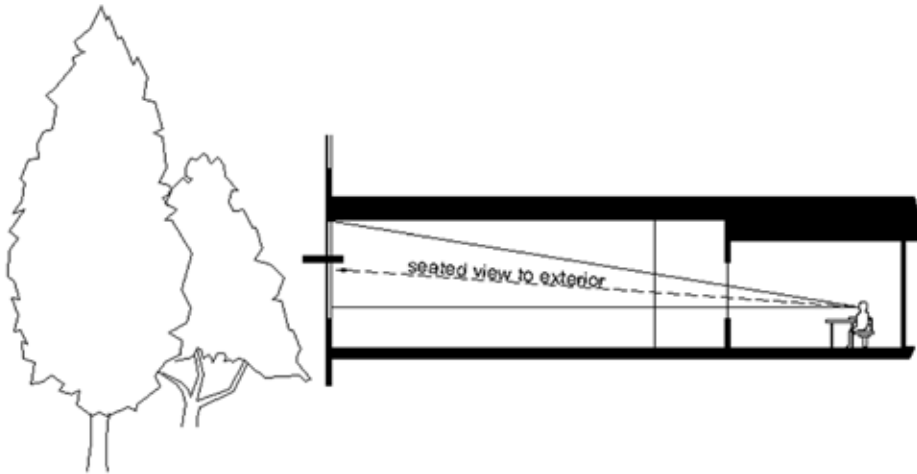


Figure 2: Horizontal View at 42°, used to confirm access to views

SS	WE	EA	MR	EQ	ID
Credit 8.2					



building use intended. This layout can be used as part of the submittal.

Commercial office and retail projects will have different design concerns to work through and demonstrate. For an office building the envelope and building geometry will be the main factors in determining whether the project can comply. Retail projects need to consider possible tenant space layouts as they relate to employee use of regularly occupied spaces and how the window placement allows views to the exterior from these spaces.

Calculations

Direct Line of Sight to Perimeter Vision Glazing

1. Create a spreadsheet and identify all regularly occupied rooms/areas. Determine the floor area of each applicable room using construction documents. Using a floor plan, construct line of sight geometries at each window to determine the fraction of the regularly occupied room/area that has direct line of sight to the outdoors. Note: line of sight can pass through interior glazing but not through doorways with solid doors.
2. For private offices, if the percentage of floor area with direct line of sight

Table 1: Determination of Compliance

Room	Regularly Occupied Floor Area [SF]	Plan Area of Direct Line of Sight to Perimeter Vision Glazing [SF]	Calculated Area of Direct Line of Sight to Perimeter Vision Glazing [SF]	Horizontal View at 42 Inches [Yes/No]	Compliant Area [SF]
101 Office	820	790	820	Yes	820
102 Conference	330	280	330	Yes	330
103 Open Office	4,935	4,641	4,641	Yes	4,641
104 Office	250	201	250	No	0
105 Office	250	175	175	Yes	175
Total	6,585				5,966
Percent Access to Views [5,966/6,585] 90.5% Credit Earned					

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Credit 8.2					

is equal to or greater than 75% (i.e., only the corners are non-compliant), you may enter the entire square footage of that room in the spreadsheet (see **Table 1**) as meeting the credit requirement. If less than 75% of the room has direct line of sight, you must estimate the compliant floor area and enter that value in the spreadsheet.

3. For multi-occupant spaces, such as open work areas and conference rooms, estimate the actual square footage with direct line of sight to perimeter vision glazing.

Horizontal View at 42 Inches

1. Using representative building sections, draw a line at 42" (average seated eye height) across the section to establish the height of the perimeter glazing and any obstruction to it. Draw one or more representative sight lines from a point at 42" in the regularly occupied space(s) to the perimeter vision glazing (see **Figure 2**).
2. For each space where the view, taken at 42" above the floor, is maintained, enter a YES in the spreadsheet in the "Horizontal View" column (see **Table 1**). If a room has direct line of site on the floor plan but does not have an unobstructed view at 42", the floor area of that room may not be counted as meeting the credit requirement and should be marked as NO in the spreadsheet.

Total the area that is determined to meet all criteria above and divide it by the total regularly occupied area to determine if the building meets the 90% access to views requirement.

Exemplary Performance

This credit may be eligible for exemplary performance under the Innovation in Design section however, there is no prescribed threshold for determination of

exemplary performance. Projects will be evaluated on a case-by-case basis.

Precertification Submittal Documentation

Provide the LEED-CS Precertification Submittal Template, which includes the following:

- Narrative describing how the project intends to accomplish the credit requirements on the credit-specific Submittal Template signed by the appropriate design team member
- Confirmation of this intent from the owner/developer on the LEED-CS Precertification Submittal Template

Certification Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

Design and Construction Credit Compliance

The following project data and calculation information is required to document credit compliance using the LEED-CS v2.0 Submittal Templates:

- Complete the template calculation spreadsheet to demonstrate overall access to views from occupied spaces. The following data is required for input in the template: occupied space identification, occupied space area (sq. ft.), and area (sq.ft.) of each occupied space with direct access to views.
- Provide copies of the applicable project drawings showing the line of sight from interior spaces through exterior windows in both plan and sectional views.
- Provide a narrative describing any special occupancy areas that have been excluded from compliance. The

narrative should include a detailed description of the space function and an explanation as to why the inclusion of views would hinder the normal tasks/function of each excluded area.

Tenant Sales or Lease Agreement Credit Compliance

This compliance method is not available for this credit.

Considerations

Cost Issues

Additional glazing required to provide access to views can increase initial costs for a project and can lead to increased heat gain if not designed properly. Glazing provides less insulating effects compared to standard walls, resulting in higher energy use and requiring additional maintenance. However, offices with sufficient natural daylight and a visual connection to the outdoor environment have proven to increase occupant productivity and comfort. Daylighting can significantly reduce artificial lighting requirements and energy costs in many commercial and industrial buildings, as well as schools, libraries and hospitals. Daylighting, combined with energy-efficient lighting and electronic ballasts, can reduce the lighting power density in some office buildings by up to 30%.

Environmental Issues

Providing access to views of the outdoors, through the incorporation of vision glazing, enables building occupants to maintain a visual connection to the surrounding environment. The additional glazed area may reduce the need for electric lighting of building interiors, resulting in decreased energy use. This conserves natural resources and reduces air pollution impacts due to energy production and consumption.

When designing for maximum views and daylighting, designers must evaluate

and balance a number of environmental factors, such as heat gain and loss, glare control, visual quality and variations in daylight availability. Appropriate shading devices, to control glare and direct beam illumination, must be utilized to provide the highest level of environmental comfort.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Analysis of the Performance of Students in Daylit Schools

www.innovativedesign.net/studentperformance.htm

Nicklas and Bailey's 1996 study of three daylit schools in North Carolina.

The Art of Daylighting

<http://www.edcmag.com/CDA/Archives/10e5869a47697010VgnVCM100000f932a8c0>

This *Environmental Design + Construction* article provides a solid introduction to daylighting.

New Buildings Institute's Productivity and Building Science Program

[www.newbuildings.org/downloads/FinalAttachments/PIER_Final_Report\(P500-03-082\).pdf](http://www.newbuildings.org/downloads/FinalAttachments/PIER_Final_Report(P500-03-082).pdf)

Provides case studies and program report on the benefits of daylighting.

Radiance Software

<http://radsite.lbl.gov>

Free daylighting simulation software from the Lawrence Berkeley National Laboratory

The Whole Building Design Guide Daylighting

www.wbdg.org/design/daylighting.php?r=ieq

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Credit 8.2					

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Lighting Controls

www.wbdg.org/design/electriclighting.php?r=ieq

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Print Media

“Daylighting Design” by Benjamin Evans, in *Time-Saver Standards for Architectural Design Data*, McGraw-Hill, Inc., 1997.

Daylighting for Sustainable Design by Mary Guzowski, McGraw-Hill, Inc., 1999.

Daylighting Performance and Design by Gregg D. Ander, John Wiley & Sons, 1997.

Sustainable Building Technical Manual, Public Technology Institute, 1996.

(www.pti.org)

Definitions

Daylighting is the controlled admission of natural light into a space through glazing with the intent of reducing or eliminating electric lighting. By utilizing solar light, daylighting creates a stimulating and productive environment for building occupants.

Direct Line of Sight to Perimeter Vision Glazing is the approach used to determine the calculated area of regularly occupied areas with direct line of sight to perimeter vision glazing. The area determination includes full height partitions and other fixed construction prior to installation of furniture.

Horizontal View at 42 Inches is the approach used to confirm that the direct line of sight to perimeter vision glazing remains available from a seated position. It uses section drawings that include the installed furniture to make the determination.

Non-Occupied Spaces include all rooms used by maintenance personnel that are not open for use by occupants. Included in this category are janitorial, storage and equipment rooms, and closets.

Non-Regularly Occupied Spaces include corridors, hallways, lobbies, break rooms, copy rooms, storage rooms, kitchens, restrooms, stairwells, etc.

Regularly Occupied Spaces are areas where workers are seated or standing as they work inside a building; in residential applications, it refers to the living and family rooms.

Vision Glazing is that portion of exterior windows above 2’6” and below 7’6” that permits a view to the outside of the project space.